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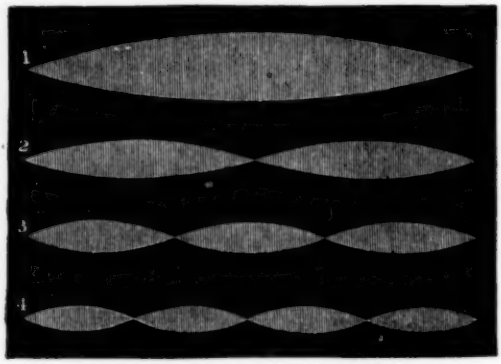
WAVE-ACTION IN NATURE.

THE waves upon water are always objects of pleasing interest. From the ripples of the pond to the billows of the ocean, their beauty and their sublimity are sources of perennial inspiration to the poet and the painter. But there is an invisible realm of air-waves of a far subtler and more wonderful order. The water-waves belong to the sensuous eye and to art, but the aërial pulsations belong to the eye of the imagination and to science, the great revelator of the super-sensuous harmonies of the universe. Water-waves afford an agreeable spectacle, and have little further concern for us; but the waves of air take hold of our highest life, for the multitudinous sounds of Nature by which we are soothed and exhilarated, all the delights of music, the pleasures of speech, and the sweet experiences of social intercourse, are made possible only through their agency. Besides, air-waves form one link in the chain of agencies by which we pass from the material to the spiritual world. The first is the capacity by which matter may be thrown into vibration; second, the properties of air by which it can take up the impulses of vibration in the form of waves; third, those properties of the mechanism of hearing by which it can take up the motion of air-pulses; and, fourth, those properties of nerves by which they can take up the tympanic vibrations and translate them into feeling or consciousness. How the last step is effected we do not know, but many of the preliminary conditions to it are understood, and to some of these we ask the reader's attention.

All sound begins in those collisions and attritions among material things by which their parts are thrown into tremors. These are almost as various in quality as the properties of material substances. The sounds we hear are but indices to the vibrations of bodies from which they proceed, and the multitude of such terms as splash, roar, ring, thud, crack, whiz, squeak, crash, illustrate the marvellous diversity of characters which material vibrations may take. In the pro-

duction of noise, the thrills of matter are transient and irregular, but, when prolonged and regular, they give rise to musical sounds. Vibration depends upon elasticity, and bodies which are capable of the protracted and measured pulsations of music must, of course, be highly elastic. We have said that bodies vibrate differently, and this depends upon the nature, form, and magnitude of the mass in motion. The vibrations of bells differ with their sizes and the metals and alloys which compose them; while wooden and metallic tubes, strained strings, and stretched membranes, illustrate the same thing. If a tense wire be plucked aside, it executes lateral vibrations which differ with its varying length, strain, and density. It may vibrate as a whole (1), Fig. 1, while, by relaxing the tension, or by touching or *damping* it at different points, it may be made to break up into different systems of vibration as shown in (2), (3), (4), Fig. 1. The points of rest in such cases are called *nodes*. Rods and tubes of wood or glass may be made to vibrate *longitudinally* by rubbing them lengthwise with the rosined fingers or a damp cloth. Fig. 2 represents a glass tube, six feet long and two inches in diameter, which, by being vigorously rubbed in this way, was set into such violent vibration that it went to pieces.

FIG. 1.

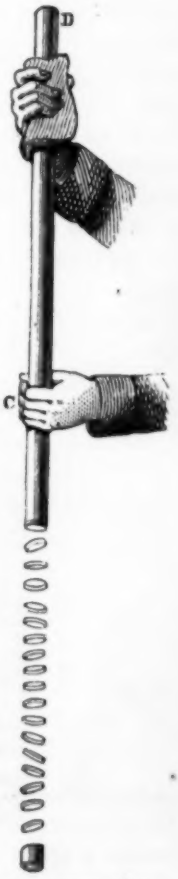


A STRING IN DIFFERENT PHASES OF VIBRATION.

If thin plates of glass or metal be clamped in the centre, and fine sand scattered over the surface, they may be set into vibration, and the sand will be tossed away from certain parts of the surface and collected in other parts, forming regular geometrical figures. The sand collects at the lines of rest, which are called *nodal lines*. Fig. 3 represents this experiment, the vibration being produced by a fiddle-bow, while the application of the fingers at different points determines the lines of rest and the geometrical figures. Fig. 4 represents a number of the beautiful patterns that were obtained by Chladni, who first drew attention to this interesting phenomenon.

Now, in order that all these multifarious and diversified tremblings of natural objects may be brought into relation with animate creatures, a common medium of communication is necessary. The air around us is such a medium. It possesses the marvellous power of taking up the numberless and ever-varying thrills of material objects, and conveying them through space with all their peculiarities. The sensitiveness of the air (if we may so speak) to the faintest tremors in material objects, and its power of transmitting their individual qualities, are most wonderful. It drinks up the infinitesimal motions of things, and diffuses them swiftly, simultaneously, and in countless myriads in all directions around.

FIG. 2.



TUBE FRACTURED BY VIBRATION.

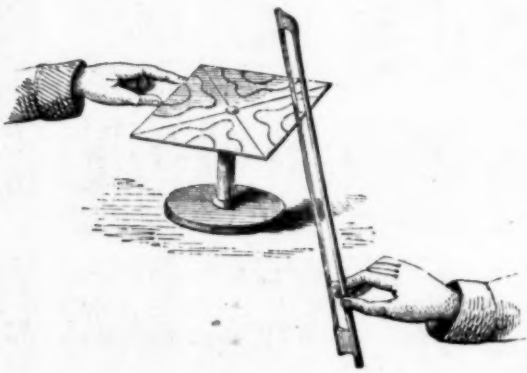
That air is the medium of sound is proved by the fact that, when vibrations occur in space void of air, the silence is not broken. If a bell suspended by a string in a vacuum be struck, nothing is heard, although, if it is in contact with the jar, the vibrations are communicated to the outer air, and sounds produced. That air transmits the kind of motion that it receives is also proved by the fact that it will take up vibrations at one point and communicate them to a distant object that is capable of vibrating in the same way.

The velocity of impulses in the air which produce sound has been well established, and all kinds of shocks—the firing of a gun, notes of a musical instrument, or the voice, whether high or low, harsh or soft—all move at the same rate. The velocity is not affected by changes in atmospheric pressure or moisture, or by rain or snow, but it is affected by wind and by temperature. The speed of sound is 1,090 feet per second at the freezing-point, and increases about one foot per second for each degree of ascent on the Fahrenheit scale. It, therefore, takes longer to hear in winter than in summer. In many parts of the country the change of temperature is so great that the velocity of sound will vary more than 100 feet a second in the different seasons. Sound moves in air with about the speed of a cannon-ball, and at a rate ten times greater than the swiftest motion of air in a hurricane. The sound produced in the open air tends to move in all directions with equal speed, but this tendency may be disturbed by various conditions. If the whole mass of air is moving in one direction, sound will travel faster with it than against it. In still air the sound of a musket-shot will be heard farthest in the direction of the impulse. Experiments have shown that a person speaking in the open air can be

heard about equally well at a distance of 100 feet in front, 75 feet on each side, and 30 feet behind. When an obstacle checks a sound in one direction it can be heard farther in others, because, as a given amount of force produces a given amount of motion, if the motion is arrested in some directions, it is increased in others.

We have now seen that air is the common vehicle of sound, and that the sound-impulse moves in all directions at a high speed. But what is it that actually moves? The particles of air are certainly not shot from the vibrating body to the ear, for then we should live in the midst of storms ten times more violent than tropical cyclones. The wonderful elastic properties of gases here come into play. The vibrations of bodies produce waves or pulses in the air. It is the same in effect as with water-waves. When we throw a stone into a quiet pool, the ripples chase each other in circles to the shore, but the water itself

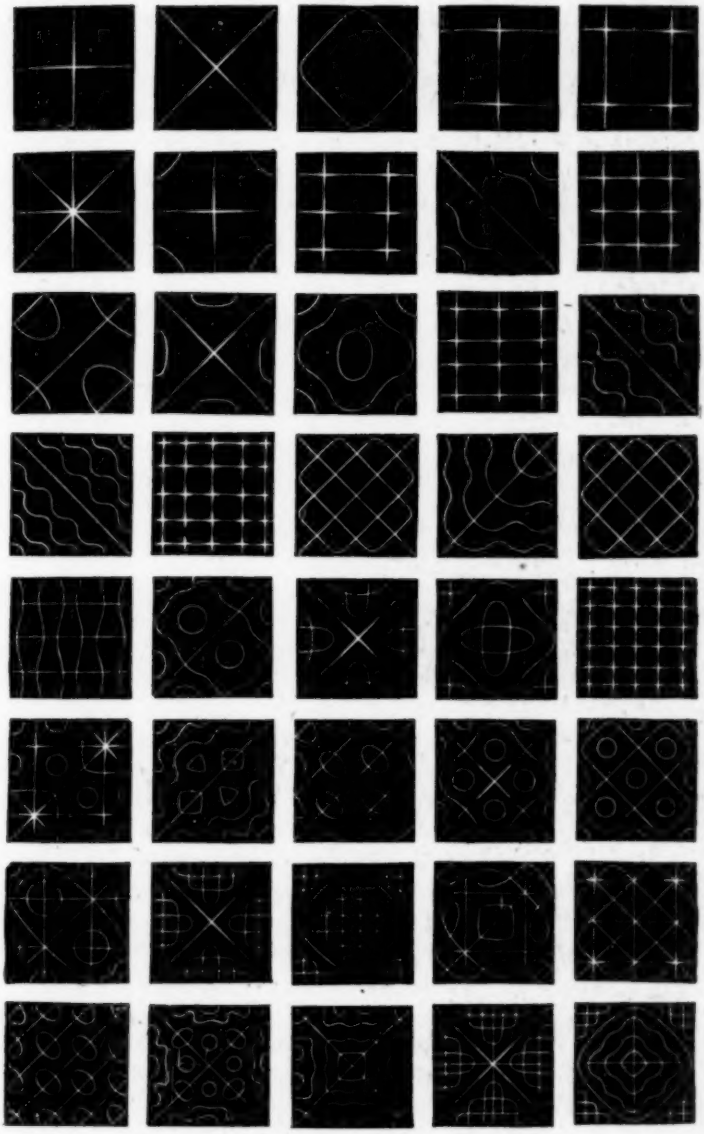
FIG. 3.



VIBRATIONS OF A CLAMPED PLATE.

does not move forward. The floating straw is not borne along, but merely rises and falls in its place, and so the particles of water only oscillate up and down in circles, and, communicating their motion to the adjacent particles, there is an outward transference of force by wave-action, and the water-particles move up and down while the wave moves forward. Air-waves exemplify the same principle, but in a different way. A vibrating body throws the contiguous air into movement, and produces the wave. But the air-particles oscillate backward and forward or in the same direction as the advancing wave. The oscillations in water are *transversal;* in air, they are said to be *longitudinal.* The mode of movement may be rudely illustrated by a row of glass balls such as are employed in the game of "Solitaire." If a dozen of them are placed in a groove in contact (Fig. 5), and one of them be withdrawn with the hand and lightly struck against its neighbor, the motion imparted to the first ball is delivered up to the second,

Fig. 4.

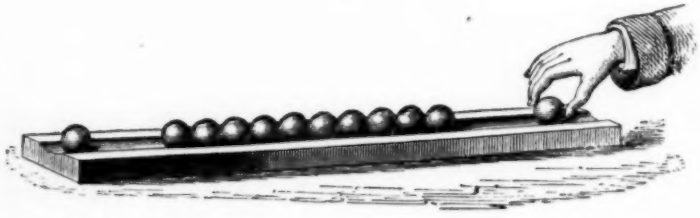


Chladni's Figures of Vibrating Plates.

that to the third, and so on, while the last ball only of the row flies away. The balls being elastic, the first one struck is not pushed from its position, but is slightly compressed, and then expanding it compresses the second, which, again expanding, compresses the third; and so there is propagated a series of compressions and expansions

through the row. In a similar way the action of a vibrating body upon the air is to produce a series of condensations and rarefactions which are sent successively forward through the atmosphere, and each condensation, with its associated rarefaction, constitutes a sonorous wave. This is illustrated in Fig. 6, where A B represents a tuning-fork in vibration. As the prong, *a*, strikes against the air, its particles are driven together or condensed in front of it, and, as the prong retreats, it leaves a partial vacuum behind. Each vibration thus gen-

Fig. 5.



Propagation of Impulses through Balls.

erates a wave. The oscillations of the air-particles are communicated to the adjacent particles, and the impulse is sent forward. In Fig. 6, *b c d* represent the condensations, and *b' c' d'* the accompanying rarefactions in the propagation of impulses through the air.

If, now, we imagine these dark and light spaces prolonged in circles round the tuning-fork, we shall have an idea of the way sound moves in all directions. We are to conceive of air-waves as bubbles or spheres, which rapidly expand from the point of vibration, and chase each other outward with the speed of musket-balls.

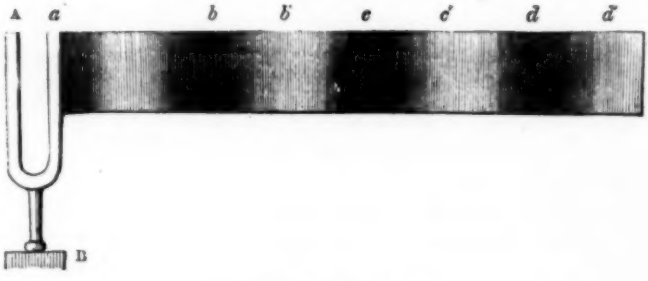
We have said that the waves of sound take place in an invisible realm, yet it is in the power of science to bring them into view. This triumph of experiment is due to a German named Toepler. Prof. Rood has given an account of it in his admirable lecture on the "Mysteries of the Voice and Ear." It depends upon the principle that, "when light which is travelling through the atmosphere meets with a denser or rarer layer, it is usually turned a little out of its straight path—a very little—but enough, sometimes, to render the layer actually visible, if proper optical means are employed." But, how is a wave to be made visible, if it moves with the speed of a cannon-ball, "which goes so fast we cannot see it?" It is by getting a glimpse of it so quickly that it has no time to move, and appears as if at rest. Those who have seen a railway-train at high speed illuminated by a flash of lightning, will remember that it appeared as if standing still. So, if a cannon-ball were passing through a darkened room, and could be illuminated by an electric flash, it would seem to be at rest in mid-air. By suitable arrangements, and the use of the electric spark, Prof.

Toepler caught the air-waves on the instant, and got a glimpse of their circular, and even their shaded aspect.

We have said that "the difference between noise and music is, that in noise the waves strike the ear irregularly, while in music they are regular, and so rapid as to blend together. Any sound which becomes continuous by rapid periodic strokes is said to be musical. "If a watch, for example, could be caused to tick with sufficient rapidity—say one hundred times a second—the ticks would lose their individuality, and blend to a musical tone. And, if the strokes of a pigeon's wings could be accomplished at the same rate, the progress of the bird through the air would be accompanied by music. In the humming-bird, the necessary rapidity is attained; and, when we pass on from birds to insects, where the vibrations are more rapid, we have a musical note as the ordinary accompaniment of the insect's flight."

Sounds vary in pitch, and the pitch depends upon the rate of vibration. The greater the number of vibrations in a second, the shorter and quicker are the waves, and the higher the tone. It has been determined, in various ways, exactly how many vibrations there are in

Fig. 6.

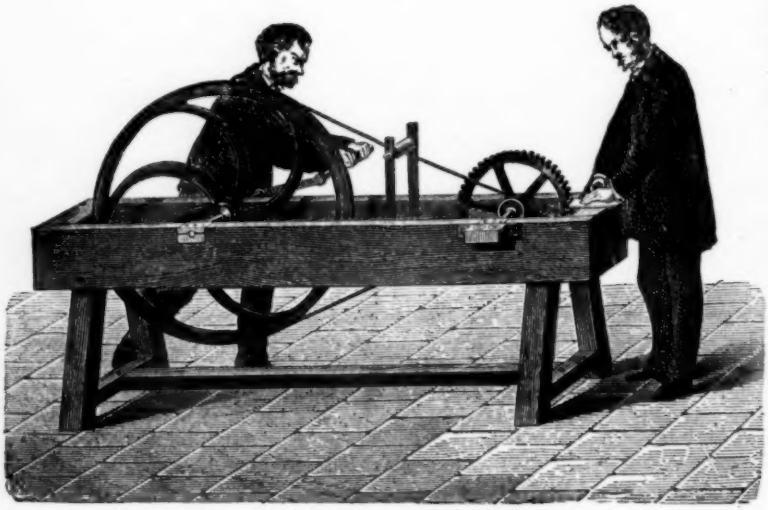


Constitution of Air-Waves

each musical note. Savart employed a toothed wheel, which could be set in motion at any desired rate of speed, and which had attached a small recording apparatus that gave the number of revolutions in a second. Fig. 7 represents the mechanism, and the mode of using it. While the wheel is in revolution, a thin visiting-card, or a piece of pasteboard, is held against its toothed edge. The card is bent a little by each tooth, as it goes by, and springs back to its first position as soon as it is released. When the wheel is turned slowly, there is heard only a succession of taps, distinctly separable one from another; but, as the rapidity of the rotations increases, the number of strokes increases also, and they soon unite to form a musical sound, while, exactly as the motion is accelerated, the sound rises in pitch. In this way it is possible to count the number of vibrations in producing every note in the musical scale.

The usual range of hearing lies between 16 vibrations in a second and about 38,000 vibrations per second. Starting with 16 vibrations per second, as the number is increased we have a series of rising musical notes, until the number is doubled, and an *octave* is produced with 32 vibrations per second. Increasing them from this point, the notes rise in pitch until they are again doubled, and we have the second octave with 64 vibrations per second. By thus ascending through 11 octaves, the number of vibrations reached would be 32,768 per second; but all the notes comprised within these limits cannot be employed in music. Tyndall states that the practical range of musical

FIG. 7.



SAVART'S APPARATUS FOR NUMBERING VIBRATIONS.

sounds is comprised between 40 and 4,000 vibrations per second, which amounts, in round numbers, to seven octaves. Helmholtz says that the deepest tone of orchestra instruments is the E of the double bass with 41¼ vibrations. The new pianos and organs generally go down to 33 vibrations. In height, the piano-forte reaches to 3,520 vibrations, or sometimes to 4,224; while the highest note of the orchestra is that of the piccolo flute, with 4,752 vibrations per second. The limits of hearing vary in different persons. The squeak of the bat, the sound of the cricket, and even the chirrup of the sparrow, cannot be heard by some persons. The limit of sensibility often varies by as much as two octaves.

Waves of water, as everybody knows, vary greatly in magnitude; the riplets of the pool may be not more than an inch in length, while the sea-waves may measure a hundred feet from crest to crest. Sound-

waves also vary greatly in magnitude, though to each rate of vibration there corresponds a definite length of wave. Knowing the rate of vibration per second, and the velocity of sound per second, lengths of waves are easily calculated. Take, for example, a tuning-fork that sounds the lowest note of the common D-flute, and it gives 288 vibrations per second. If, now, it be struck in still air, at the freezing-point, the foremost wave will reach a distance of 1,090 feet, at the end of a second, while the chain of waves which connects it with the vibrating fork will be 288 in number: each wave-link will therefore be about 3 feet 9 inches long. With few vibrations and deep tones, waves are long, while, with rapid vibrations and shrill tones, waves are correspondingly short. Within the limits of hearing, sound-waves vary in length, from 70 feet to a half an inch. "The waves generated by a man's organs of voice in common conversation are from 8 to 12 feet; those of a woman are from 2 to 4 feet in length. Hence, a woman's ordinary pitch, in the lower sounds of conversation, is more than an octave above a man's; in the higher sounds it is two octaves."

But, because the numbers of their oscillations are exactly determined, we must not suppose that the motions are so simple, for, as Prof. Rood remarks, smooth and clean-cut waves but seldom reach the ear. There are compound vibrations which give complexity to wave-figures. The large waves at sea are often covered by smaller waves, so that the water-particles obey double impulses, and swing in double oscillations. It was illustrated, in Fig. 1, that a string may vibrate as a whole, or in various subdivisions. When a string or any other body vibrates as a whole, it produces its lowest note, which is called the fundamental note. But the fundamental note is never perfectly pure. It is not possible to sound the string as a whole, without at the same time causing the vibrations of its parts. But, as these shorter vibrations are quicker, they yield notes of a higher pitch, which mingle with the fundamental note, and alter its quality. These accompanying higher notes may be in harmony with the fundamental note (when they are called *harmonics*), or they may not harmonize with it. The sounds emitted by the *parts* of a vibrating body are called *overtones*, and it is possible for a string to furnish as many as 20 or 30 of these. The mingling of the overtones with the fundamental one determines the *timbre* of sound. It is this which gives their peculiar character to different musical instruments, and enables us to distinguish them. A clarinet and a violin may give the same fundamental note, but their overtones are so different that the instruments are never confounded.

Sound-waves are not only transmitted by the air, but also by liquids and solids. That water will convey musical sounds is shown by the following experiment: Fig. 8 represents a tube a yard long, set upon the wooden tray A B, with a funnel at the top, and filled with water. A tuning-fork is attached to a little wooden foot, set into vibration, and the foot is then dipped into the water without touching the sides

of the funnel. The vibrations are transmitted by the liquid to the tray below, which is thrown into tremors, and a swelling musical sound is the result.

Fig. 8.

Vibrations conveyed through Water.

The following beautiful experiment, described by Prof. Tyndall, shows how music may be transmitted by an ordinary wooden rod. In a room two floors beneath his lecture-room, there was a piano upon which an artist was playing, but the audience could not hear it. A rod of deal, with its lower end resting upon the sounding-board of the piano, extended upward through the two floors, its upper end being exposed before the lecture-table. But still no sound was heard. A violin was then placed upon the end of the rod, which was thrown into resonance by the ascending thrills, and instantly the music of the piano was given out in the lecture-room. A guitar and a harp were substituted for the violin, and with the same result. The vibrations of the piano-strings were communicated to the sounding-board, they traversed the long rod, were reproduced by the resonant bodies above, the air was carved into waves, and the whole musical composition was delivered to the listening audience.

The instrument of hearing in man consists of an external orifice about an inch and a half deep in adults, which is closed at the bottom by the circular tympanic membrane. This membrane, though moderately strong, is quite thin, and almost transparent. It is made up

of fine fibres, some radiating from the central part to the circumference, and others arranged in concentric rings. It is kept gently on the stretch by two small muscles, one of which draws it tighter, and the other loosens it, by acting upon a chain of small bones. We shall not undertake to describe the curious and complicated anatomy of the inner ear—the drum, containing air, the curious chain-work of minute vibrating bones, the labyrinth filled with water containing little crystalline particles and fine elastic bristles, and where the delicate fibres of the auditory nerve commence. "There is also," says Tyndall, "in the labyrinth a wonderful organ discovered by the Marchese Corti, which is, to all appearance, a musical instrument, with its chords so stretched as to accept vibrations of different periods, and transmit them to the nerve-filaments which traverse the organ. Within the ears of men, and without their knowledge or contrivance, this lute of 3,000 strings (as Kölliker estimates) has existed for ages, accepting the music of the outer world, and rendering it fit for reception by the brain. Each musical tremor which falls upon this organ selects from its tensioned fibres the one appropriate to its own pitch, and throws that fibre into unisonant vibration. And thus, no matter how complicated the motion of the external air may be, those microscopic strings can analyze it, and reveal the constituents of which it is composed." By this wonderful apparatus are all the tremulous movements of the outer world translated to the world within. How the auditory nerve transmits its impressions is not a matter of demonstration, but the probability is great that it transmits them as it receives them as impulses of motion—waves of force that are conveyed to the brain and expended in the production of those physical motions which are the material conditions and accompaniments of consciousness. That the organ of feeling and thought is itself a sphere of vibrations and wave-actions traversing in all directions the millions of microscopic fibres which pervade the encephalon, will be thought absurd by many: but we know that wave-action is a part of the method of Nature; that it produces the most wonderful effects in all the common forms of matter; that the brain is a material instrument in the closest physical relation with the outward order; and that material changes of some kind within it are the concomitants of its exalted functions. That there should be unity in the whole scheme does not appear irrational.

Be this as it may, the marvels of what is known are inexhaustible. Could we see what takes place in a room when a tuning-fork is in vibration, giving out a single note, we should behold all the particles of the air agitated in tremulous sympathy, and filling the space with swiftly-expanding spheres of spectral beauty. Or, were the effect produced by several instruments concurrently played, we should see the forms in countless variety carving the air into ever-changing figures of geometrical harmony, and creating the perfect music of geometrical form. Such a revelation is impossible, from the swiftness of movement,

which would foil the eye; but it would be also impossible, because the complications of movement would confuse it. But, where the optical sense fails, the auditory sense succeeds. The membrane of the ear receives the torrent of motion, and transmits it with all its harmonies. In an orchestra, where scores of instruments are playing through the whole compass of the scale, the air is cut into waves by every complexity of vibration—grave tones mingle with shrill, soft with harsh, fundamentals are merged in overtones, and the storm of impulses is shot with the speed of rifle-bullets against the tympanum; and yet there is no confusion. In all their infinite diversity of qualities the waves are legible to the little membrane. It vibrates to the lowest and to the highest, to each and all, and telegraphs the whole performance with incomprehensible exactness to its cerebral destination; and an exquisite work of art is produced in the sphere of pleasurable feeling and critical intelligence.

Our glance at this fascinating subject has been very imperfect, but, if any care to pursue it, we recommend them to the admirable book of Prof. Tyndall, "On Sound," to which we are indebted for the foregoing illustrations, and for many of the facts stated.

INSTINCT IN INSECTS.

By GEORGE POUCHET.

TRANSLATED FROM THE FRENCH, BY A. R. MACDONOUGH, ESQ.

I.

WHAT is instinct? In what does it differ from intelligence? What explanation can be given of it in the present state of the sciences of life? All these are questions to which a positive answer is asked for the first time in our day. Philosophers and moralists do not in our time concern themselves with the relations or the differences between instinct and intelligence; for they have no means of solving problems that particularly concern biology. Without going farther back, we remember Descartes's strange notion of animal machines, adopted by Bossuet, and the whole seventeenth century; but at this time biologists in their turn attack the problem; anatomy and physiology will perhaps give us the solution sought in vain at the hands of philosophic and religious systems since the days of Aristotle and St. Thomas.

George Cuvier was the first to draw a clear distinction between instinct and intelligence, in the second edition of the "Animal Kingdom" (1829), in which he digests the works published during the course of several years, by his brother Frédéric. The latter, placed in control of the menagerie of the museum, believed that it pertained

to the duties of his post to make a course of connected studies upon the animals committed to his charge: he thought, as Geoffroy Saint-Hilaire did, that such is the sole purpose of establishments of that kind. "There exists in animals," Cuvier tells us, "a faculty distinct from intelligence, which we term instinct. It makes them do acts which each individual performs without ever having seen them done, and which are repeated, from generation to generation, invariably the same. Without having learned, the animal knows; it knows from its birth, and knows so well, that it never makes a mistake, even in acts of extreme complexity, the secret of which it seems to bring with it into the world. Young ducks hatched under a hen go straight to the nearest piece of water, and boldly plunge and swim, in spite of their foster-mother's cries and distress. The squirrel lays up its winter stock of hazel-nuts and filberts, before it knows what winter is. The shepherd's dog and the pointer know how to do the duties expected of them, through a gift at birth. The bird hatched in a cage and reared a captive, if set free, will build a nest like that its parents built, on the same tree, of the same materials, in the same shape. The spider, more amazing still, weaves without any lessons the geometric net-work of its web; and the untaught bee builds its comb. Man too has his instinct, as animals have. By instinct the new-born child feels for and finds its mother's breast; but instinctive phenomena in man are less easy to determine, and their discovery demands careful research, because intelligence usually veils them. And yet intelligence is not wanting in animals either, only with them instinct has that predominance which intelligence takes in man."

With the exception of a few mistakes in details, Cuvier marked very accurately the line between the instinctive and the intellectual faculties, but he went no further. His character and disposition gave him but little taste for penetrating into problems of that kind. With a lofty disdain to which posterity has done justice, he left to his rival Geoffroy Saint-Hilaire the care of inquiring into the origins of vital manifestations. Cuvier affirmed simply that every species received at its beginning a certain share of intelligence, with a certain provision of instinct, so wisely proportioned as to insure the permanence of that species till the end of time, or at least till the next revolution in our globe. The intelligent race does its part with its faculties as it can; they must suffice for it. The race without intelligence, to make up for its want, brings into the world a supply of instinct which aids it to make its way. This odd theory of compensation, instinct and intellectual faculties respectively complementing each other, misled Cuvier; it agreed with the general scope of his doctrine; but it does not agree with facts. Those among animals that present the most highly-developed instinct are, unquestionably, the insects; the silky tissues of cocoons, the structures wrought by wasps, the beautiful works that are treasured in cabinets, bear witness to astonishing in-

stinctive faculties; every thing seems to be instinct with the insects, and, if Cuvier's idea be adopted, it ought in general to be very poorly endowed as regards intelligence. We shall presently see that the truth is completely the reverse.

Besides, Cuvier had no very accurate knowledge of insects, which in his classification he degraded to a place below molluscs. We cannot address the same reproach to M. Emile Blanchard, who pursues the natural history of articulated animals, at the Jardin des Plantes. We regret keenly that in his late work on the "Transformations, Habits, and Instincts of Insects," he has not thought fit to follow the suggestions of such a title, and to dwell a little on that twofold subject of intelligence and instinct which would gain by being clearly stated. His usual studies and the direction of his labors enable M. Blanchard better than any one else to complete a blank which must be supposed one of choice only, in his work. The learned professor of the museum goes on from Cuvier's starting-point with him, and, with Flourens in his last work ("Comparative Psychology," 1865), M. Blanchard distinguishes instinct from intelligence, but he stops there. He makes no attempt whatever to measure the reciprocal influence of these two kinds of faculties in the very complex acts of insect-life; and, above all, he refrains from the study of their intelligence, full of interest as it is. "Individuals of the same species," he says, "always perform the same works without having learned any thing; instinct alone guides them." Yet, together with this instinct, as M. Blanchard himself admits, there are faculties of intellect, which offer greater difficulties of study by reason of the existence of those instinctive faculties. These very difficulties make the study more worthy of attention. How are the two classes of faculties combined? If that winged mite had nothing but the instincts that urge it, those alone would make it interesting; how is that interest increased, when in that tiny body instinct is paired with reflection that analyzes sensations, and will that determines movements! what a study might we find in these intellectual faculties used by so perfect an instinct! Does it not become indispensable to measure these faculties exactly in the case in which instinct is most developed? Suppose we were to find, contrary to Cuvier's opinion, that instinct, far from being inversely proportioned to the degree of intelligence, is just the reverse, and is greater, according as intelligence is more active.

This really is the truth, and it is important to fix this first point clearly in the study of instinct. Human inferiority in point of instinct is perhaps only apparent, since education hardly allows us to guess what we should be without it. We know from the history of more than one child found wild in the woods, especially from that of the idiot boy so well studied by Itard, what amazing instincts may be displayed by a human creature, even one absolutely without understanding, when abandoned to itself. Among all animals, insects are assuredly

those in which instinct is most developed; we except neither birds with their nests, nor beavers with their dams. Among insects, those in which the highest expression of instinct is noted are bees, that build cells like the work of profound geometry; and particularly ants, acting with instincts yet higher, which seem to approach those perhaps smothered by education in man. A Genevese, Peter Huber, made these known to us. His book (1810) crowns a period of remarkable studies upon insects. Before his time, as far back as 1705, a woman, Mlle. Sybille de Merian, crossed the ocean and made a voyage to Surinam, to paint the caterpillars of the tropics; then after her come Réaumur, Da Geer, Bonnet, who watches night and day his flea, the daughter of five virgin generations, and, when it dies, writes to all Europe to disclaim any responsibility for the event. The pursuit grows a passion. Lyonnet passes his life in describing, drawing, and engraving the anatomy of the willow-caterpillar. Enthusiasm works miracles; Francis Huber, the father of the man of ants, although blind, performs the marvel of making wonderful discoveries as to things taking place in the inner darkness of beehives. Peter Huber, the son, is lost and absorbed in those societies of the ants to which he devotes his studies. While all Europe is agitated by coalitions, nothing from without reaches him.

Peter Huber observes and experiments with rare sagacity. No fact escapes him; he may remark upon it or explain it ill, but he notes it most accurately. His observations have not been contradicted; his experiments still remain patterns of care and patience. He peopled with ants, his garden, the terrace of his house, his study, his tables, which were turned into a kind of hives, and, lest this new dwelling might be unsatisfactory to the ants, and in order that they might keep at work in it, he made rain and fair weather for them; his rain-making consisting in rubbing his hand for hours at a time over a wet brush. In brief, he supplied them so richly with tempting dainties and weather-contrivances, that at last they wanted nothing better than their chance home, a bureau-drawer. Did he not even one day cherish the fantastic notion of bringing up the larvæ of his ants by feeding by hand? We cannot resist loving him for his attachment to these little, thinking beings. He meditated long over one decisive experiment—nothing less than the question of setting two colonies of ants at war on the floor of his study. He hesitated and lingered to awake the *casus belli* which should be the signal of slaughter; he devised pretexts to adjourn the dreadful scene. "I thought over this experiment for a long time," he says, "and I constantly postponed it, because I had grown to be very fond of my captives." This recalls one of Réaumur's sayings. He observes with what celerity humble-bees rebuild their nest of moss after it has been opened to examine the inside, an intrusion which these insects allow much more patiently than honey-bees do, and he adds: "If the moss from above is thrown down

pretty near to the foot of the nest, as one would naturally do without even thinking that it ought to be done to save the insects some trouble, they very soon busy themselves with putting it back in its place." To save the insects some trouble! What a love for Nature the eighteenth century had, and how differently things are done nowadays! Our entomologists study their ant-hills spade in hand; a stroke of the pick into the mysteries of that underground dwelling costs their feverish passion for inquiry nothing, and yet what a spectacle rewards such barbarity! If the spade uncovers a house of tawny ants (*Formica fusca*), we see under the arched top a labyrinth of low rooms, of galleries and passages, which penetrates the ground and leads to spacious chambers full of nymphæ in their cocoons, or of larvæ almost as motionless. That ant, larger than the others, which is busily coming and going, is a female; for the common ants, the workmen, have no sex; naturalists call them neuters. The female lays eggs, and some workers, surrounding her, take these, one by one, and pile them in little heaps. The worms, when hatched, would perish without the workers, being able only to lift their heads to show their want of food; a worker comes up and lets them take from between its mandibles such nourishing juices as it has brought from its quest in the fields. When the hour comes for carrying all these papooses into the sun, they carry them up and spread them out on the arched top. If the heat is too strong, or if it rains, they bring them back again at once into rooms of suitable temperature. When the time of their transformation comes, the larva has spun itself a cocoon, but is quite unable to get out of it alone. It is the duty of the workers again to extract it; they cut the silk, tear the shell, release the weak, new-grown creature, and then the old empty cocoons are stored away in a remote chamber. Thus are produced males, females, and neuters. The males and females fly off; some females will come back to lay eggs in the ant-hill; the neuters do not leave it. As soon as they have gained a little strength, they set about all those labors that instinct teaches them—the repair and keeping in order of the ant-hill, inside and without, carrying of useful materials, pursuing plant-lice, and gathering stores of all kinds. Assuredly, these instincts alone are very wonderful; but there remains still another to be spoken of, peculiarly conferred on certain species, and which is indisputably the highest of all those we know among animals.

Peter Huber discovered it on the afternoon of the 17th of June, 1804. The date is a memorable one for biology. He was walking in the environs of Geneva, between four and five o'clock in the evening, when he saw a regiment of great red ants crossing the road. They marched in good order, with a front of three or four inches, and in a column eight or ten feet long. Huber followed them, crossed a hedge with them, and found himself in a meadow. The high grass plainly hindered the march of the army, yet it did not disband; it had its ob-

ject, and reached it. This was the nest of another species of ants, blackish-gray ones, whose hill rose in the grass twenty steps from the hedge. A few blackish-gray ones were scattered about the hill; as soon as these perceived the enemy, they darted upon the strangers, while others hurry into the galleries to give the alarm. The besieged ants come out in a body. The assailants dash upon them, and, after a very short but very spirited struggle, drive the black-gray ones back to the bottom of their holes. One army corps presses after them into the galleries, while other groups labor to make themselves an opening with their teeth into the lateral parts of the hill. They succeed, and the remainder of the troop makes its way into the besieged city by the breach. Peter Huber had seen battles and exterminations of ants before this; he supposed they were slaughtering each other in the depths of the caverns. What was his amazement, after three or four minutes, when he saw the assailants issue hurriedly forth again, each holding between its mandibles a larva or a nympha of the conquered tribe! The aggressors took exactly the same road again by which they had come, passed through the hedge, crossed the road, at the same place, and made their way, still loaded with their prey, toward a field of ripe grain, into which the honest citizen of Geneva, respecting another's property, refrained, with regret, from following them.

This expedition, worthy of the annals of barbarian piracy, inspired Huber with an amazement easy to understand. He examined, and discovered, to his great surprise, that some ant-hills were inhabited in common by two kinds of ants, forming two castes. He designates one of these by the name of "amazon or legionary ants; a name strongly suggesting their martial character," he says. The others he calls, very justly, "auxiliaries." The amazons do not work; their duty is fighting and carrying off the nymphæ and larvæ. They choose the hour toward sunset for their warlike raids against the industrious and peaceable tribes of the neighborhood. Whenever the weather is fine, they sally out thus, and levy their tribute of flesh. The auxiliaries, for their part, are employed in all internal duties, and in keeping up and repairing the dwelling. They alone open and close the entrances to the ant-hill, night and morning; they alone (in the species observed by P. Huber) go after provisions, for they feed the whole establishment, even the legionaries, which are idle except when on their forays; they rear with equal care the larvæ of the legionaries and those that are stolen; they alone, in fine, seem to decide upon the material interests of the community, the requisite enlargements, the need of emigration, and the place suitable for it. Peter Huber made one experiment that shows very plainly the absolute dependence of the amazons upon their associates. These fierce warriors do not understand any household work. Huber put thirty amazons into a glazed drawer, covered with earth on the bottom, with a certain number of larvæ and of nymphæ, both of their own kind and of the auxiliary species. A little

honey in a corner was provided for the support of the colony. At first, the amazons seemed to pay some attention to the larvæ, carrying them about here and there, but they soon left them. They did not know how to provide themselves with food. At the end of two days some had already died of hunger close alongside the honey-drops, all were languishing, and they had not even built a chamber. "I was sorry for them," says Huber. He put an auxiliary into the drawer. This solitary one restored order, made a house in the earth, gathered the larvæ into it, released several nymphæ of both kinds that were ready to leave the cocoon, and at last saved the lives of those among the amazons that still had breath.

Peter Huber refrains from any comments in describing all these wonders; he leaves each one, as he says, at liberty to draw any conclusions he pleases. This one conclusion is inevitable: We do, then, find among animals artificial societies, communities of beings strangers in race, yet living together, contributing, toward one common end, their different qualities and their individual efforts. The hive is always one family only. A mixed ant-hill is inhabited by individuals belonging to species at least as different as the horse, the ass, the zebra—so different sometimes that zoologists have classed them in distinct genera (*Polyergus formica*). Like provinces subject to the same form of government, every ant-hill has, nevertheless, its local history, explained by external circumstances, by conditions of neighborhood and boundary. Each one has only the principle of its organization in common with the rest. The same legionaries have sometimes one species of auxiliaries and sometimes another, the black-grey or the mason ant, whichever is within their reach, sometimes both together; or there may be two kinds of legionaries, the "polyergus" and the dark-red, living in the same hill, with one or two species of auxiliaries. Some naturalists, Darwin among others, call these frankly "slave-holders," and the others "slaves." These names are unfair. We must guard against any mistake as to the very peculiar nature of the relations existing between the two castes. Each fills a special part in the community, and neither exercises control or despotism in it. If the association, at the outset, rests on violence and abduction, nothing has ever given rise to a suspicion that there is any thing else in a mixed ant-hill than a collection of individuals kept together by special instincts. These names of "slavery" and "republic," applied to such a form of life, are quite void of meaning. Any allusion to politics, to systems, or doctrines of equality, is wholly out of place here; biology alone has the right of giving a name to a social state which is its peculiar subject of study; this territory belongs to it alone.

We have selected these instances because they furnish the most striking proof both of the perfection that instinct may reach, and of the degree of intelligence of which animals are capable which are placed by their nature at an immeasurable distance from man. Peter

Huber did not clearly draw the distinction, nor could he do so in his time, between that which is instinct and that which is the share of intelligence in those acts which he witnessed. It is clear that these two orders of faculties are constantly combined. It is by reason of their perfection in instinct that intelligence appears so clearly in these little beings. The construction of the ant-hill is an act of instinct; the choice and distribution of its materials partake of intelligence. A thousand traits reveal the thought which perceives, deliberates, wills, executes. We may cite the observed fact of a crowd of ants dragging with great effort a beetle's wing toward their hole. The opening is too small, the wing will not go in. The workers drop it a moment, tear down a piece of the wall, and renew their attempt. Some push it from outside, others drag it from within. Fruitless effort! The superb spoil, which will make an entire ceiling, will not pass yet; they drop it once more; the breach is widened, and the wing at last is swallowed up in the cavern, where perhaps ten partitions must be torn down to carry it to the proper place. The wing once got in, they rebuild the wall, and restore its former dimensions to the entrance. We cannot cite, in the case of monkeys watched in captivity in menageries, a single instance so clearly showing deliberation and common judgment.

The social phenomena presented by the higher animals are unfortunately very little known. We know scarcely any thing of what goes on in a habitation of beavers; we know nothing of the habits of the republican sparrow, which builds a city for its nest; the insect communities are the most perfect ones that have been studied hitherto. So soon as a society exists, there are understanding and concurrence of all at every moment to reach a definite object. No zoologist now doubts that insects of the same species may communicate with each other, under certain circumstances, by a language of which the methods elude us. Blanchard says of the ant: "It has its ideas, and communicates them;" but a singular detail of the history of the sacred scarabee shows this still more clearly. The female, as we know, wraps up her newly-laid egg in a ball of manure, the nourishment for the coming grub. The point now is to transport the ball into a suitable place, where it may be buried. The insect rolls along, with its hind-claws, or, if necessary, hoists with its head, this little world, in which the Egyptians found an emblem for their myths. Sometimes the journey is pretty long; the ball, lifted to the ridge of a mole-hill, rolls down the other side, and so much is gained. But, if a rut or a crevice is encountered, the precious globe drops to the bottom, and would be hopelessly lost if the scarabee had only its own strength to depend on for mounting that steep wall. It struggles in vain, and begins again twenty times over; at last it seems to desert its load, and flies off. Wait and watch; after a little while you will see the insect coming back, but not alone now. It is followed by two, three, four, five com-

panions, which all drop down into the place pointed out, combine their efforts, drag out the ball, and set it on its path again. What did the scarabee say to its comrades? how did it make itself understood? how did it bring them back with it? It is not possible to make any positive answer to these questions; what is beyond dispute is, that there was in this case a concert of intelligences knowing how to understand each other and to come together. Nothing more is needed for the assertion that the insect judges, wills, and perhaps speaks, a language of which we know as yet neither the signs nor the organs.

Cuvier, then, was in error when he announced that instinct in animals is in an inverse ratio to their intelligence. The contrary seems rather to be true, and it is at least probable that in those intelligences of insects which feel, will, understand, deliberate, there are, on a finer scale, differences similar to those we remark in the higher animals. The faculty is common to all, but with shades as marked among the wild beasts of menageries as among our domestic animals. One is cross, and another jealous; this one is good-tempered, that other quarrelsome, faithful to the house, or a vagabond in the streets—all are more or less intelligent. In the lower animals these differences have not been as closely observed; in the first place, they are probably less distinctly marked, and in any case they are much more difficult to observe for reasons of all kinds. The small size of the being, its life wholly alien to our own, the predominance of instinct, are all so many impediments; but, on the other hand, the acts we see them perform under our very eyes, the admitted existence of faculties that may be compared with our own, and those of a relatively high order, allow of very little doubt that not only do insects possess a remarkably-developed intelligence, but that this intelligence presents, in consequence of its very development, individual variations, just as in the higher animals.

This is already a great advance upon Descartes, whose strange theory no one at this day, that we are aware of, undertakes to defend; but this is not all—a new step has been taken in these later times. We are beginning, with our better knowledge, to ask whether those intellectual and instinctive faculties, arranged by Cuvier in two parallel series, may not have some common bond, so that one would flow from the other, and instinct, after all, be definitely a product of intelligence. The question has its importance. Instinct would then no longer be one of those essential properties of living beings which absolutely elude our comprehension, such as thought in the brain, contraction in the muscles, the electricity of the eel, or the gleam of the glow-worm; it would be accessible, like all dependent phenomena, to our processes of experiment and investigation.

Darwin is entitled to the credit of having taken the question into this entirely new region. This bold attempt to found the scientific study of instinct is found rather indefinitely in the "Origin of Spe-

cies." Darwin does not enter on the problem with deliberate purpose as a physiologist. He continues to be what he is in the whole work, the zoologist, exclusively occupied with his great theory: he foresees and meets objections; he has particularly anticipated those that might be brought against him in the name of instinct; and he gives, in a few pages, a more complete study of instinct than any philosopher had made before him, and the first study ever made by aid of experiment. He ignores instinct as an essential property, and treats it as a function—that is, he explains it. Instinct, as he holds, is nothing but a result from the intellectual faculties, properly so called, modified in a particular way under the twofold power of habit and inherited influence.

Inherited tendency, like intelligence, is one of those properties peculiar to living beings of which we can prove the existence, while its principle completely and absolutely baffles investigation. When we attempt to pierce the mystery by which the plant that springs from the seed, the bird that grows from the yelk, will be more like the plant or the bird it proceeds from than like any other, we confront the impenetrable unknown. Hereditary tendency does not merely carry down from one generation to another all the imaginable modifications of form, size, coloring; it extends to the cerebral faculties, transmitted doubtless by the help of some physical peculiarity of the organ of intelligence. This is what is called the spirit of race, which decides that one people shall be born brave and crafty, like the Greeks of Homer; industrious, like the Chinese; traders, like the Jews; or hunters, like the red-skin. This is, if we choose to term it so, a kind of instinct that education sometimes allows us to control, but never eradicates. As the wolf, fattened in the kennel, ends by going back to his wretched life of the woods, the child of a savage reared in the midst of civilization preserves in his mind, as upon his features, the deep, hereditary stamp of his origin. Habit, almost as much as hereditary tendency, is another mysterious faculty which we recognize without being able to explain it. Some act, most difficult in appearance, which required on the part of our brain a considerable effort of will and all our mental activity, at last surprises us by almost performing itself. We might say that attention and reflection have gone down into our limbs, which perform the most delicate tasks, and protect themselves against attacks from without, while the mind, occupied with something else, is pursuing a different object.—*Revue des Deux Mondes.*

THE DOCTRINE OF NATURAL SELECTION.[1]

By ALFRED R. WALLACE.

NOTWITHSTANDING the objections which are still made to the theory of Natural Selection, on the ground that it is either a pure hypothesis not founded on any demonstrable facts, or a mere truism which can lead to no useful results, we find it year by year sinking deeper into the minds of thinking men, and applied, more and more frequently, to elucidate problems of the highest importance. In the works now before us we have this application made by two eminent writers, one a politician, the other a naturalist, as a means of working out so much of the complex problem of human progress as more especially interests them.

Mr. Bagehot takes for granted that early progress of man which resulted in his separation into strongly-marked races, in his acquisition of language, and of the rudiments of those moral and intellectual faculties which all men possess; and his object is to work out the steps by which he advanced to the condition in which the dawn of history finds him—aggregated into distinct societies known as tribes or nations, subject to various forms of government, influenced by various beliefs and prejudices, and the slave of habits and customs which often seem to us not only absurd and useless, but even positively injurious. Now, every one of these beliefs or customs, or these aggregations of men into groups having some common characteristics, must have been useful at the time they originated; and a great feature of Mr. Bagehot's little book is his showing how even the most unpromising of these, as we now regard them, might have been a positive step in advance when they first appeared. His main idea is, that what was wanted in those early times was some means of combining men in societies, whether by the action of some common belief or common danger, or by the power of some ruler or tyrant. The mere fact of obedience to a ruler was at first much more important than what was done by means of the obedience. So, any superstition or any custom, even if it originated in the grossest delusion, and produced positively bad results, might yet, by forming a bond of union more perfect than any other then existing, give the primitive tribe subject to it such a relative advantage over the disconnected families around them as to lead to their increase and permanent survival in the struggle for ex-

[1] "Physics and Politics; or, Thoughts on the Application of the Principles of 'Natural Selection' and 'Inheritance' to Political Society." By Walter Bagehot. (King & Co., 1872.)

"Histoire des Sciences et des Savants depuis deux Siècles, suivie d'autres Études sur les Sujets Scientifiques, en particulier sur la Sélection dans l'Espèce Humaine." Par Alphonse de Candolle. (Genève: H. Georg, 1873.)

istence. In those early days war was perhaps the most powerful means of forcing men to combined action, and might therefore have been necessary for the ultimate development of civilization. Freedom of opinion was then a positive evil, for it would lead to independent action, the very thing it was most essential to get rid of. In early times isolation was an advantage, in order that these incipient societies might not be broken up by intermixture, and it was only after a large number of such little groups, each with its own idiosyncrasies, habits, and beliefs, had been formed, that it became advantageous for them to meet to intermingle or to struggle together, and the stronger to drive out or exterminate the weaker. Out of the great number of petty tribes thus formed, only a few had the qualities which led to a further advancement. The rest were either exterminated or driven out into remote and inaccessible or inhospitable districts, and some of those are the "savages" which still exist on the earth, serving as a measure of the vast progress of the human race. Yet even these never show us the condition of the primitive man; they are men who advanced up to a certain point and then became stationary:

"Their progress was arrested at various points; but nowhere, not even in the hill-tribes of India, not even in the Andaman Islands, not even in the savages of Terra del Fuego, do we find men who have not got some way. They have made their little progress in a hundred different ways; they have framed with infinite assiduity a hundred curious habits; they have, so to say, *screwed* themselves into the uncomfortable corners of a complex life, which is odd and dreary, but yet is possible. And the corners are never the same in any two parts of the world. Our record begins with a thousand unchanging edifices, but it shows traces of previous building. In historic times there has been but little progress, in prehistoric times there must have been much."

Again our author shows how valuable must have been the institution of caste in a certain stage of progress. It established the division of labor, led to great perfection in many arts, and rendered government easy. Caste nations would at first have a great advantage over non-caste nations, would conquer them, and increase at their expense. But a caste nation at last becomes stationary; for a habit of action and a type of mind which it can with difficulty get rid of are established in each caste. When this is the case, non-caste nations soon catch them up, and rapidly leave them far behind.

This outline will give some idea of the way in which Mr. Bagehot discusses an immense variety of topics connected with the progress of societies and nations, and the development of their distinctive peculiarities. The book is somewhat discursive and sketchy, and it contains many statements and ideas of doubtful accuracy, but it shows an abundance of ingenious and original thought. Many will demur to the view that mere accident and imitation have been the origin of marked national peculiarities; such as those which distinguish the German, Irish, French, English, and Yankees: "The accident of some predominant

person possessing certain peculiarities set the fashion, and it has been imitated to this day." And again: "Great models for good or evil sometimes appear among men who follow them either to improvement or degradation." This is said to be one of the chief agents in "nation-making," but a much better one seems to be the affinity of like for like, which brings and keeps together those of like morals, or religion, or social habits; but both are probably far inferior to the long-continued action of external Nature on the organism, not merely as it acts in the country now inhabited by the particular nation, but by its action during remote ages and throughout all the migrations and intermixtures that our ancestors have ever undergone. We also find many broad statements as to the low state of morality and of intellect in all prehistoric men, which facts hardly warrant, but this is too wide a question to be entered upon here. In the concluding chapter, "The Age of Discussion," there are some excellent remarks on the restlessness and desire for immediate action which civilized men inherit from their savage ancestors, and how much it has hindered true progress; and the following passage, with which we will conclude the notice of Mr. Bagehot's book, might do much good if, by means of any skilful surgical operation, it could be firmly fixed in the minds of our legislators and of the public:

"If it had not been for quiet people, who sat still and studied the sections of the cone; if other people had not sat still and worked out the doctrine of chances, the most 'dreamy moonshine,' as the purely practical mind would consider, of all human pursuits; if 'idle star-gazers' had not watched long and carefully the motions of the heavenly bodies—our modern astronomy would have been impossible; and, without astronomy, 'our ships, our colonies, our seamen,' all that makes modern life, could not have existed. Ages of quiet, sedentary, thinking people were required before that noisy existence began, and without those pale, preliminary students it never could have been brought into being. And nine-tenths of modern science is, in this respect, the same; it is the produce of men whom their contemporaries thought dreamers—who were laughed at for caring for what did not concern them—who, as the proverb went, 'walked into a well from looking at the stars'—who were believed to be useless, if any one could be such. And the conclusion is plain that, if there had been more such people; if the world had not laughed at those there were; if, rather, it had encouraged them—there would have been a great accumulation of proved science ages before there was. It was the irritable activity, 'the wish to be doing something,' that prevented it. Most men inherited a nature too eager and too restless to find out things; and, even worse—with their idle clamor they 'disturbed the brooding hen,' they would not let those be quiet who wished to be so, and out of whose calm thought much good might have come forth. If we consider how much good science has done, and how much it is doing for mankind, and, if the over-activity of men is proved to be the cause why science came so late into the world, and is so small and scanty still, that will convince most people that our over-activity is a very great evil."

In the second work, of which we have given the title, the veteran botanist, Alphonse de Candolle, sets forth his ideas on many subjects

not immediately connected with the science in which he is so great an authority. The most important, though not the longest, essay in the volume is that on "Selection in the Human Race," in which he arrives at some results which differ considerably from those of previous writers. In a section on "Selection in Human Societies or Nations," we find a somewhat novel generalization as to the progress and decay of nations. Beginning with small, independent states, we see a gradual fusion of these into larger and larger nations, sometimes voluntary, sometimes by conquest, but the fusion always goes on, and tends to become more and more complete, till we have enormous aggregations of people under one government, in which local institutions gradually disappear, and result in an almost complete political and social uniformity. Then commences decay; for the individual is so small a unit, and so powerless to influence the government, that the mass of men resign themselves to passive obedience. There is then no longer any force to resist internal or external enemies, and by means of one or the other the "vast fabric" is dismembered, or falls in ruins. The Roman Empire and the Spanish possessions in America are examples of this process in the past; the Russian Empire and our Indian possessions will inevitably follow the same order of events in a not very distant future.

Although M. de Candolle is a firm believer in Natural Selection, he takes great pains to show how very irregular and uncertain it is in its effects. The constant struggles and wars among savages, for example, might be supposed to lead to so rigid a selection that all would be nearly equally strong and powerful; and the fact that some savages are so weak and incapable as they are shows, he thinks, that the action of natural selection has been checked by various incidental causes. He omits to notice, however, that the struggle between man and the lower animals was at first the severest, and probably had a considerable influence in determining race-characters. It may be something more than accidental coincidence that the most powerful of all savages —the negroes—inhabit a country where dangerous wild beasts most abound; while the weakest of all—the Australians—do not come into contact with a single wild animal of which they need be afraid.

Selection among barbarous nations will often favor cunning, lying, and baseness; vice will gain the advantage, and nothing good will be selected but physical beauty. Civilization is defined by the preponderance of three facts—the restriction of the use of force to legitimate defence and the repression of illegitimate violence, speciality of professions and of functions, and individual liberty of opinion and action under the general restriction of not injuring others. By the application of the above tests we can determine the comparative civilization of nations; but too much civilization is often a great danger, for it inevitably leads to such a softening of manners, such a hatred of bloodshed, cruelty, and injustice, as to expose a nation to conquest by

its more warlike and less scrupulous neighbors. Progress in civilization must necessarily be very slow, and to be permanent must pervade all classes and all the surrounding nations; and it is because past civilizations have been too partial that there have been so many relapses into comparative barbarism. All this is carefully worked out, and is well worthy of attention.

In the last section, on the probable future of the human race, we have some remarkable speculations, very different from the somewhat utopian views held by most evolutionists, but founded, nevertheless, on certain very practical considerations. In the next few hundred or a thousand years the chief alterations will be the extinction of all the less dominant races, and the partition of the world among the three great persistent types, the whites, blacks, and Chinese, each of which will have occupied those portions of the globe for which they are best adapted. But, taking a more extended glance into the future of 50,000 or 100,000 years hence, and supposing that no cosmical changes occur to destroy, wholly or partially, the human race, there are certain well-ascertained facts on which to found a notion of what must by that time have occurred. In the first place, all the coal and all the metals available will then have been exhausted, and, even if men succeed in finding other sources of heat, and are able to extract the metals thinly diffused through the soil, yet these products must become far dearer and less available for general use than now. Railroads and steamships, and every thing that depends upon the possession of large quantities of cheap metals, will then be impossible, and sedentary agricultural populations in warm and fertile regions will be the best off. Population will have lingered longest around the greatest masses of coal and iron, but will finally become most densely aggregated within the tropics. But another and more serious change is going on, which will result in the gradual diminution and deterioration of the terrestrial surface. Assuming the undoubted fact that all our existing land is wearing away and being carried into the sea, but, by a strange oversight, leaving out altogether the counteracting internal forces, which for countless ages past seem always to have raised ample tracts above the sea as fast as subaërial denudation has lowered them, it is argued that, even if all the land does not disappear and so man become finally extinct, yet the land will become less varied, and will consist chiefly of a few flat and parched-up plains, and volcanic or coralline islands. Population will by this time necessarily have much diminished, but it is thought that an intelligent and persevering race may even then prosper. "They will enjoy the happiness which results from a peaceable existence, for, without metals or combustibles, it will be difficult to form fleets to rule the seas, or great armies to ravage the land;" and the conclusion is that "such are the probabilities according to the actual course of things." Now, although we cannot admit this to be a probability on the grounds stated by M. de Candolle, it does seem a

probability, at some more distant epoch, on other grounds. The great depths of the oceans extend over wide areas, whereas the great heights of the land are only narrow ridges and peaks; hence it has been calculated that the mean height of the land is only 1,000, while the mean depth of the sea is about 15,000 feet. But the sea is 2½ times as extensive as the land, so that the bulk or mass of the land above the sea-level will be only about one thirty-seventh of the mass of the ocean. Now, does not this small proportion of bulk of land to water render it highly probable that the forces of elevation and depression should sometimes cause the total or almost total submersion of the land? Of such an epoch no geological record could be left because there could be no strata formed, except from the *débris* of coral-islands, and such a period of destruction of the greater part of terrestrial life may have repeatedly occurred between the period when the several Primary or Secondary formations were deposited. At all events, with such a proportion of land and sea surface as now exists, with such a small bulk of land above the enormous bulk of water, and with no known cause why the dry land rather than the sea-bottom should be constantly elevated, we must admit it to be almost certain that great fluctuations of the area of the land must occur, and that, while those fluctuations could not very considerably increase the area of the land they might immensely diminish it. There is here, therefore, a cause for the possible depopulation of the earth likely to occur much sooner than any cosmical catastrophe.

The largest and most elaborate essay in the volume is that on the "History of the Sciences and of Scientific Men for the last Two Centuries." In this the author endeavors to arrive at certain conclusions as to the progress of science under different conditions and in different countries, the influence of political institutions and of heredity, and various other phenomena, by a method which is novel and ingenious. He takes account only of the men honored as foreign associates or members by the three great European scientific bodies, the Royal Society of London and the Paris and Berlin Academies. By this means he avoids all personal bias, and secures, on the whole, impartiality. The tables drawn out by this method are examined in every possible way, and the results worked out in the greatest detail. The main conclusion arrived at is the determination of a series of eighteen causes favorable to the progress of science; and it is shown that a large proportion of these are present in a considerable degree in countries where science flourishes, while they are almost wholly absent in barbarous or semi-civilized countries where science does not exist.

Another interesting essay is that on the importance for science of a dominant language, and it contains some very curious facts as to the way in which the English language is spreading on the Continent. M. de Candolle believes that in less than two centuries English will be

the dominant language, and will be almost exclusively used in scientific works.

There are also short but very interesting essays on methods of teaching drawing and developing the observing powers of children, on statistics and free-will, and on a few other subjects of less importance, all of which are treated in a thoughtful manner, and illustrate one of the views on which much stress is laid in this work, viz., that the mental faculties which render a man great in any science are not special, but would enable him to attain equal eminence in many other branches of science or in any professional or political career.—*Nature.*

THE BLACK DEATH IN NEW ENGLAND.

By HEZEKIAH BUTTERWORTH, Esq.

THE ancient leprosy, the red plague, and the disease known in Europe as the Black Death, have ceased to afflict mankind. They seem to belong to the evils of the past; their banishment is due to human progress, to a better knowledge of hygiene, and a clearer understanding of the causes that develop infection and produce contagious and epidemic diseases. It is an interesting question to ask, "Will not the small-pox and the cholera, whose effects science has already modified, become extinct diseases?"

The disease known as the black death made its first appearance in Europe at Constantinople in 1347. It was brought there from Asia, probably from the northern coasts of the Black Sea. From Turkey it gradually spread over Europe, almost depopulating whole districts as it travelled north. Florence was terribly smitten. Boccaccio, in the preface to his "Decameron," has left us an account of the sweeping destruction of the Florentines by the scourge, which one who reads can never forget. From Florence it travelled into Spain, swept over France, and crossed the Straits of Dover.

It made its appearance in England late in the summer of 1348. From June to December of that year there was an almost incessant fall of rain. The ground was continually damp, and the streams were polluted by surface drainage. When the sun shone, it was through a misty sky, producing a vapory heat, particularly unhealthy and enervating. In August, a few cases of a disease supposed to be the black death were reported. In September the plague was surely among the people. In November it reached London, and from the capital it rapidly spread into all parts of the kingdom.

The symptoms of this terrible disease, which usually proved fatal, were inflammatory boils and swelling of the glands, similar to those

that appear in the worst eruptive fevers, with black patches all over the skin, from which the disease received the name Black Death. The patient was next seized with violent vomitings of blood; he sometimes died at once, and he seldom survived more than two days. It is stated that, toward the end of the pestilence, many lives were saved by puncturing the boils.

It was a fearful time. The population of England and Wales numbered probably between three and four millions, and of these at least one-half, or more than a million persons, perished. Stowe says that the scourge "so wasted and spoyled the people that scarce the tenth person of all sorts was left alive." Another old writer says: "There died an innumerable sort, for no man but God only knew how many." In six months from January 1st there died in the city of Norwich more than 57,000 persons. In the graveyard of Spittle Croft, thirteen acres of land, which was used for the burial of the dead, because the London graveyards were "choke full," there were buried 50,000 persons. Parliament was prorogued in January, on account of the plague having broken out in Westminster, and again in March, on account of the increase of the disease. On the 16th of June, 1350, an important public regulation was made, "because," as the law ran, "a great part of our people is dead of the plague."

Not only the people but the cattle were infected. The disease was highly contagious. Death was in the air. "The pestilential breath of the sick who spat blood," says Hecker, "caused a terrible contagion far and near, for even the vicinity of those who had fallen of the plague was certain death, so that parents abandoned their infected children, and all the ties of kindred were dissolved!"

Half the population, or more than a million souls! What a stretch of the imagination does it require to cover such an appalling calamity! Cities were reduced to towns; towns to hamlets. The work of the husbandman ceased. The dead were unburied, and lay in the fields rotting in the sun. People stayed in their own houses, often half clothed and half famished, waiting for the destroyer to come.

In the year 1664 a similar visitation of the plague came upon London. The disease was perhaps not as swift and violent as had been the black death three hundred years before, but it was of the same general character. It broke out in Drury Lane in December. It had been raging for a considerable period in Holland, and the minds of the English people had been filled with apprehension for months. If Defoe's narrative is true, the people believed that they had supernatural warnings of the impending catastrophe. The symptoms of this disorder were similar to the black death, except that it was usually preceded by dimness of vision, and the discolored patches on the body were livid, instead of black. At the beginning of the following summer the disease fearfully increased. We may get an idea of the scene at the beginning of the calamity, from some little incidents recorded in the

journal of Pepys. "June 7th," says this writer, "was the hottest that ever I felt in my life. This day, much against my will, did I see in Drury Lane two or three houses marked with a red cross upon the doors, and 'Lord, have mercy upon us!' writ there—a sad sight to me, being the first of the kind I ever saw." Again, on the 17th of the same month, he says: "It struck me very deep this afternoon, going with a hackney coach down Holborn, from the Lord Treasurer's, I found the coachman to drive *easily and easily*, and the coach stood still. He told me that he was suddenly struck very sick and almost blind. I took another coach, with a sad heart for the poor man, and fearing for myself also, lest he should have been struck with the plague."

As the calamity increased, shops were closed, dwellings were left empty, and the public thoroughfares were deserted. The markets were removed beyond the city-walls, coaches were seldom seen, except when people were fleeing from the city; a solemn stillness prevailed in many districts, and grass grew in the streets. People might be heard crying out of the windows for help, but the cry returned echoless. Some went mad; some rushed into the river, and ended their tortures by suicide. On a single night in the month of September 10,000 people died.

Many incidents of this terrible visitation are preserved, the best known being from the pen of Defoe. Rev. Thomas Vincent describes some touching scenes, of which he himself was a witness. "Among other spectacles," he says, "two, methought, were very affecting; one of a woman coming alone and weeping by the door where I lived, with a little coffin under her arm, carrying it to the new church-yard. I did judge that it was the mother of the child, and that all the family besides were dead."

An old writer thus describes an impressive scene in London during the reign of the plague:

"O unrejoicing Sabbath! not of yore
Did thy sweet evenings die along the Thames
Thus silently. Now, every sail is furled,
The oar hath dropped from out the rower's hand,
And on thou flowest in lifeless majesty,
River of a desert lately filled with joy!
O'er all the mighty wilderness of stone
The air is clear and cloudless, as the sea
Above the gliding ship. All fires are dead,
And not one single wreath of smoke ascends
Above the stillness of the towers and spires.
How idly hangs that arch magnificent
Across the idle river! Not a speck
Is seen to move along it. There it hangs
Still as a rainbow in the pathless sky."

—*John Wilson.*

These are old facts, and are generally well known to the readers of old histories. But it may not be as well known to our readers that the black death, or at least a most malignant form of the true plague, prevailed in North America during the first part of the seventeenth century, sweeping off the Indian tribes on the Atlantic coast, and especially the tribes of New England. In the charter of New England, granted by James I., and bearing date of November 3, 1620, the king states "that he had been given certainly to know, that, within these late years, there hath, by God's visitation, reigned a wonderful plague, etc., to the depopulation of that whole territory, so that there is not left, for many leagues together in a manner, any that do claim or challenge any kind of interest therein."

"These late years" seem to have been 1617, 1618, and 1619. Its ravages from the Narragansett Bay to the Penobscot were of the most fearful character, constantly destroying one-fourth, and, according to some authorities, one-thirtieth of the natives. The old Indians gave a frightful account of it to the Pilgrims, saying that the victims had "died in heaps," and that the disease swept them off so rapidly that "the living were not able to bury the dead."

It is stated that, of the Indians inhabiting Patuxet, Squanto only remained. Norton, in his "New England Canaan" (Amsterdam, 1637), says: "They died in heaps, as they lay in their houses, and the living that were able to shift for themselves would run away and let them dy, and let their carkases ly above the ground without burill. For, in the place where many inhabited, there hath been but one left alive to tell what became of the rest, the living being, it seems, not able to bury the dead. They were left for crowes, kites, and vermine, to pray upon. And the bones and skulls, upon the several places of their habitation, made such a spectacle after my coming into these parts that, as I travelled in that forest near the Massachusetts, it seemed to me a new-found Golgotha." We should add that Mr. Norton came to this country in 1622.

Sir Fernando Gorges, who sent a ship to the East Atlantic coast at this period, tells us that, according to the reports given to him, those of the savages who had escaped the wars had been sore afflicted with the plague: "Notwithstanding, *Vines*" (his navigator), "and the rest with him that lay in the cabins with those people who died, did not so much as feel their heads ache while they stayed there."

It has been stated that the tribe of the Wampanoags was reduced from thirty thousand to a few hundred people, which will account for the small number of braves who appeared with Massasoit during his early visits to Plymouth. The Massachusetts, a tribe about as large as the Wampanoags, according to an early authority, were reduced in like proportion.

Some have supposed that this disease was the yellow fever, because an old Indian had told one of the early historians that the bodies of

the deceased turned the color of his blanket, which was yellow. But, in most allusions to it, we find it spoken of as the true plague, or the pestilence in its worst and most destructive form.

The solitude of the forest at this time must have been most solemn and awe-inspiring. Of villages once populous, nothing remained but decaying huts, tenanted by birds and beasts, who had left white and bare the human bones scattered around. The desolations of Athens, of Constantinople, of Florence, and of London, were all unequalled by the spectacle of depopulation that has been presented on our very shores.

The Indian plague becomes an interesting fact of medical science, since it has been supposed that our climate has prophylactic virtues which render the pestilence, that, after an interval of centuries, has again and again ravaged Europe, impossible. We have strong reason to hope that the progress of science has banished this swift minister of death from the civilized races, and that even the modified forms of the disease are gradually yielding and disappearing. Still it is by no means certain that it may not come travelling from the East again, and, if so, we are no more protected by territorial or climatic influences than the inhabitants of the Old World. At least, so we might reasonably infer from this last fearful but interesting chapter of history.

THE NEW PSYCHOLOGY.[1]

By DOUGLAS A. SPAULDING.

TO give readers some idea of the contents of a good book is very often the most useful thing a reviewer can do. Unfortunately, that course is not open to us in the present instance. The subject is too vast. We cannot exhibit the grandeur; we can only in a few general phrases express our admiration of the profound, all-embracing philosophy of which the work before us is an instalment. The doctrine of evolution, when taken up by Mr. Spencer, was little more than a crochet. He has made it the idea of the age. In its presence other systems of philosophy are hushed; they cease their strife, and become its servants, while all the sciences do it homage. The place that the doctrine of evolution has secured in the minds of those who think for the educated public may be indicated by a few names taken just as they occur. Mr. Darwin's works, the novels of George Eliot, Mr. Tylor's "Primitive Culture," Dr. Bastian's "Beginnings of Life," and Mr. Bagehot's "Physics and Politics," have hardly anything in com-

[1] "The Principles of Psychology." In two volumes. By Herbert Spencer. New York: D. Appleton & Co.

mon but the idea of evolution, with which they are all more or less imbued. In a word, we have but one other thinker with whom, in point of influence on the higher thought of this, and probably of several succeeding generations, Mr. Spencer can be classed; it does not need saying that that other is Mr. J. S. Mill.

As we cannot present such an outline of Mr. Spencer's system of psychology as would make it generally intelligible, the purpose of directing attention to the work will perhaps be best served by selecting as the subject of remark one or two points to which the presence of the controversial element may lend a special interest. After pointing out that the cardinal fact brought to light, when nervous action is looked at entirely from the objective point of view, is, that the amount and heterogeneity of motion exhibited by the various living creatures are greater or less in proportion to the development of the nervous system, Mr. Spencer comes to the vexed question of the relation between nervous phenomena and the phenomena of consciousness. This is a subject about which, in its more subtle aspects, there is much uncertainty and some confusion of thought. It may be taken as established, that every mode of consciousness is a concomitant of some nervous change. Given certain physical conditions, accompanied by a special state of consciousness, and there is every reason to believe that physical conditions in every respect identical will always be attended by a similar state of consciousness. This, and not more than this, we think, was intended by Mr. Spencer in his chapter on Æsthophysiology. Nevertheless, several able men have, it would appear, been led to suppose that he countenances a kind of materialism (not using the word to imply any thing objectionable; for why not be materialists, if materialism be truth?), which forms no part of his philosophy. To give precision and emphasis to what we say, we would take the liberty to refer to the position taken up by Dr. Bastian in his remarkably able and important work on the "Beginnings of Life." The expression that definitely raises the issue of which we wish to speak, and which at the same time fixes Dr. Bastian to a view not in harmony with the teaching of Mr. Spencer, is the following: "We have not yet been able to show that there is evolved, during brain action, an amount of heat, or other mode of physical energy, less than there would have been had not the Sensations been felt and the Thoughts thought;" but he believes that this is the case. Our present object is not so much to show that here speculation has got on the wrong track, as that, if we understand Mr. Spencer, it is not his opinion that any thing of this kind takes place; though certainly some ambiguous phrases might be held to convey this meaning. We have mentioned the significant fact that the size of the nervous system holds a pretty constant relation to the amount and heterogeneity of motion generated. The implication is, that none of the motion evolved during nervous action disappears from the object world, passes into consciousness in the same

sense that physicists speak of momentum passing into heat; that whether consciousness arise or not, there will be for the molecular motion set up in the nerve-substance exactly the same mechanical equivalents. Whether, for example, those ganglia that in the body of each one of us are employed in carrying on what we call reflex action, are so many distinct seats of consciousness, like so many separate animals, an idea for which much has been said, or whether the nerve-changes that go on in these ganglia have no subjective side; in either case the objective facts will remain the same. If consciousness is evolved, it is not at the expense of a single oscillation of a molecule disappearing from the object-world. No doubt it is hard to conceive consciousness arising in this apparently self-created way; but, if any suppose that by using phrases that would assimilate mind to motion they ease the difficulty, they but delude themselves. It is as easy to think of consciousness arising out of nothing, if they will, as to conceive it as manufactured out of motion; that is to say, the one and the other proposition are alike absolutely unthinkable. On this point Mr. Spencer writes: "Can we think of the subjective and objective activities as the same? Can the oscillations of a molecule be presented in consciousness side by side with a nervous shock, and the two be recognized as one? No effort enables us to assimilate them. That a unit of feeling has nothing in common with a unit of motion, becomes more than ever manifest when we bring the two into juxtaposition." Mr. Spencer's idea is that feeling and nervous action are two faces of the same ontological something—a view that prohibits the notion of the one passing into or being expended in producing the other. The conclusion is, that the transformations of physical energy remain unaffected by the presence or absence of consciousness.

Psychology has as yet been made a serious study by only a few individuals. Accordingly, it is only the more striking and easily grasped peculiarities of Mr. Spencer's system that can be referred to with advantage. Of these, the most imposing, and the one of which the educated public have already a slight second-hand acquaintance, is the doctrine that the brain and nervous system is an organized register of the experiences of past generations, that consequently the intelligence and character of individuals and of races depend much more on this, on the experiences of their ancestors, than on their individual experiences. The flood of light thrown by this conception on so many things previously dark and unfathomable, its power of bringing about harmony where before there was nothing but confusion and unsatisfactory wrangling, ought to have been sufficient to have secured it a universally favorable reception. This, however, has not been the case, and partly, perhaps, because of the very merits that recommend it. It may be that veterans who have won their laurels on, say, the battle-field of innate ideas, love the old controversy, and are not anxious to learn that both sides were right and both wrong. Moreover, it is

the misfortune of this important addition to psychology, that it shows that previous workers in this field of inquiry have at times been laboring in the dark to solve problems like in kind with the famous difficulty of accounting for the supposed fact that the weight of a vessel of water is not increased by the addition of a live fish. For instance, should Mr. Spencer be right, the celebrated theory of the Will, elaborated by Prof. Bain, the able representative of the individual-experience psychology, becomes a highly-ingenious account of what does not happen. Thus, the new doctrine can be accepted only at the expense of giving up much of what has hitherto passed for mental science.

The following sentences will serve to indicate Mr. Spencer's position: "The ability to coördinate impressions, and to perform the appropriate actions, always implies the preëxistence of certain nerves arranged in a certain way. What is the meaning of the human brain? It is that the many *established* relations among its parts stand for so many *established* relations among the psychical changes. Each of the constant connections among the fibres of the cerebral masses answers to some constant connection of phenomena in the experiences of the race. . . . Those who contend that knowledge results wholly from the experiences of the individual, ignoring as they do the mental evolution which accompanies the autogenous development of the nervous system, fall into an error as great as if they were to ascribe all bodily growth and structure to exercise, forgetting the innate tendency to assume the adult form. . . . The doctrine that all the desires, all the sentiments, are generated by the experiences of the individual, is so glaringly at variance with facts, that I cannot but wonder how any one should ever have entertained it." The circumstances which account for the existence of the individual-experience psychology, and which enable it still to hold out as a rival of the more advanced form that Mr. Spencer has given to the science, are these: (1) the immaturity of the human infant at birth; (2) the lack of precise knowledge with regard to the mental peculiarities of the lower animals; (3) the still popular notion that the human mind does not resemble the mental constitution of the animals; that it is of a different order. Of course this last is nowadays little more than a popular superstition, nevertheless it can be taken advantage of; and an argument to the effect that the mental operations of the animals are, to all appearance, so very different from the workings of the human mind that they can supply nothing more than a worthless, if not a misleading analogy, has a very specious and scientific look about it in the eyes of those who are not very well acquainted with the subject. Our ignorance of animal psychology may be still more boldly drawn on in defence of the theory under consideration. With a hyper-scientific caution, its advocates refuse to take into account any thing (incompatible with their theory) concerning any one species of animal that has not been proved by a very overwhelmingly large number of very accurate observations. And

they find it possible to maintain that it still remains unproved that any species of animal possesses either knowledge or skill not wholly acquired by each individual. A better acquaintance with the mental peculiarities of the animals is certainly a desideratum, and we hope that this rich field of investigation will not long remain uncultivated. In *Macmillan's Magazine* for February there is an account of a series of observations and experiments on young animals by the present writer, which, unless they can be discredited, may reasonably be expected to go far to establish the fact of instinct, the fact of innate knowledge and unacquired skill; in other words, the phenomena on which the experience-psychology, minus the doctrine of inheritance, can throw no light whatever. Now, had not Mr. Darwin banished from every scientific mind the hypothesis of the miraculous creation of each distinct species of animal just as we see it, with all its strange organs, and, to most people, still stranger instincts, the presumption against a system of human psychology that not only can give no account of the most striking phenomena in the mental life of the animals, but which strongly inclines those who hold it to pronounce such phenomena incredible, might not have been so apparent. But, in the present state of our scientific knowledge, such a psychology, professing to be a complete system, is self-condemned. In its fundamental principles the science of mind must be the same for all living creatures. Further, if man be, as is now believed, but the highest, the last, the most complex product of evolution, a system professing to be an analysis and exposition of his mind, yet confessing itself incompetent to deal with the necessarily simpler mental processes of lower creatures, must surely feel itself in an uncomfortably anomalous position.

It is, however, on the first-mentioned circumstance, the immaturity of the infant at birth, that most stress can be laid. The newly-born babe cannot raise its hand to its mouth, and doubtless for a long time after birth it has no consciousness of the axiom, "Things that are equal to the same thing are equal to one another." The helplessness of infancy is pointed to as furnishing ocular demonstration of the doctrine that, whatever may be the case with the animals, all human knowledge, all human ability to perform useful actions, must be wholly the result of associations formed in the life-history of each individual. But it can surely require little argument to show that this is an entirely unwarranted assumption. It might as well be maintained that, because a child is born without teeth and without hair, the subsequent appearance of these must be referred wholly to the operation of external forces. Of the several lines of argument that might here be employed, let us, for the sake of freshness, take the analogy from the lower animals. We are not aware that it can be asserted, as the result of prearranged and careful observations, that any creature at the instant of birth exhibits any of the higher instincts. A number of iso-

lated and more or less accidental observations have been recorded; and apparently on the strength of these Mr. Spencer has made the following unqualified statement. "A chick, immediately it comes out of the egg, not only balances itself and runs about, but picks up fragments of food, thus showing us that it can adjust its muscular movements in a way appropriate for grasping an object in a position that is accurately perceived." The fact is, that, on emerging from the shell, the chick can no more do any thing of all this than can the new-born child run about and gather blackberries. But between the two there is this great difference, that, whereas the chick can pick about perfectly in less than twenty-four hours, the child is not similarly master of its movements in as many months. Our present point is, that it can be shown by experiment that the performances of the chick a day old, which involve the perceptions of distance and direction by the eye and the ear, and of many other qualities of external things, are not in any degree the results of its individual experiences. Let it now be remembered that, in the absence of conclusive evidence to the contrary, it has been considered a safe position to hold that the early knowledge and intelligent action of the chicken "may be, after all, nothing more than very rapid acquisitions, the result of that experimentation, prompted by the inborn or spontaneous activity." May we now, on the other side, similarly presume, until the contrary is shown, that the more tardy progress of the infant is not because its mental constitution has to be built up from the foundation out of the primitive elements of consciousness, which the chicken's has not, but rather because the child comes into the world in a state of greater physical, and therefore mental immaturity? The progress of the infant, however, has been so continually spoken of as if it were a visible process of unaided acquisition, that it may give some surprise when it is asserted from the other side that we have no sufficiently accurate acquaintance with the alleged acquisitions of infancy to justify the doctrine that they are different in kind from the unfolding of the inherited instincts of the chicken. To give definiteness to the attitude taken up, we would say, for example, that the facts concerning the early movements of the two lambs and the calf observed by Prof. Bain, and which, looked at from his point of view, were strong confirmation of the doctrine of individual acquisition, may be just as readily interpreted as the unfolding of inherited powers; which, as far as we know, start into perfect action at the moment of birth, in no single instance. From observations on several newly-dropped calves, the facts corresponding substantially with those recorded by Prof. Bain, the present writer could draw no conclusive evidence in favor of either the one theory or the other. One observation, however, may here be mentioned that seemed rather to favor the doctrine of inheritance. A calf one hour old, which had been staggering about on its legs for ten minutes, stepped out at the open door of the byre. It no sooner found itself in the

open air than it began to frisk and dance; it was left entirely to itself, and, when it had been on its legs fifteen minutes, it—apparently in obedience to the feeling of fatigue—deliberately lay down, folding in its limbs after the established manner of its kind. This is all we know about calves; about children we know nothing at all. And it may fairly be asked how, when called in question, the assumption that underlies such statements as the following can be made good. We quote from Prof. Bain's account of the growth of voluntary power. He says: "The infant is unable to masticate; a morsel put into its mouth at first usually tumbles out. But, if there occur spontaneous movements of the tongue, mouth, or jaw, giving birth to a strong relish, these movements are sustained, and begin to be associated with the sensations; so that, after a time, there grows up a firm connection." Bearing in mind that, when born, the child has no occasion for the power of masticating solid food; that the ability to suck, which involves an equally complex series of muscular adjustments, is what it requires, and this it has by instinct; bearing all this in mind, the question is, Why may not the innate ability to masticate be developed by the time it is required quite as spontaneously as the teeth used in the operation? Take a parallel. The feeble nestling when it leaves the shell is blind. One of the several very pronounced and interesting instincts it exhibits at this stage is, that in response to certain sounds it opens its mouth and struggles to hold up its head to be fed. Several weeks later it begins to pick for itself. Now, we put the question, Is this second mode of filling its stomach to be considered a pure acquisition, while its original plan must certainly be regarded as pure instinct? No one, we think, will venture to answer in the affirmative; the more so as this is a case that may any day be put to the test of experiment. Where, then, is the evidence that the analogous progress from drawing milk to masticating solid food is of a different kind?—*Nature.*

OCEAN-CABLES.

By Sir JAMES ANDERSON.

THIS is by no means a new subject for investigation, but in the present day I am certain that it will be instructive to many among the thousands who are now interested in this class of property to have their attention briefly called to all that has been done to make submarine cables a sound property.

Eleven years ago there was a joint committee appointed by the "Lords of the Committee of Privy Council for Trade and Atlantic Telegraphy, to inquire into the construction of submarine cables, to-

gether with other evidence." Attention is called in the report to the "remarkable fact that in almost all cases small cables had been found liable to mishaps, while the heavier the cable had been the greater had been its durability." The report is full and complete, and establishes principles which up to the present time have uniformly guaranteed success, while the neglect of them has as uniformly resulted in partial loss or failure.

The loss of cables was found to be attributable to the following causes: First, and the most important of all, from imperfect manufacture, resulting without doubt, prior to this date, from inexperience of the materials for insulating the copper wire, and from ignorance of the fact discovered by Prof. Thomson about 1856, viz., that some kinds of copper wire were no better than iron for the purpose of conductivity, and that it required carefully-selected copper to give the desired standard, which may be represented by a copper wire one-tenth of an inch in diameter, being equal to an iron wire one-third of an inch in diameter for electrical purposes. All cables manufactured previous to this date had no advantage from this discovery.

There appear to have been mechanical difficulties in keeping the copper conductor in the centre of the insulating medium, so that the copper was sometimes found to be almost visible under the light film of gutta-percha which covered it. The electric current soon weakened this film, stronger currents were used to overcome the weakness of the signals, and the cable was soon destroyed. Experience about this time had established that a cable from the commencement of its manufacture to the time of its being laid should be tested under water and under pressure, and kept as much as possible under all the conditions in which it was meant to continue.

Attempts to lay cables from sailing-ships towed by steamers was another source of failure. The ships had not enough steerage-way when met with strong head-winds, and too much slack was paid out. It was difficult under such circumstances to steer a straight course, and sailing-ships possessed no power of being readily stopped when a fault or accident occurred.

Many accidents happened from inexperience in the method of paying out cables; at the present day the wonder is, that they should have succeeded so well with the rude methods and inexperience which then existed, and not that there should have been many failures and much recrimination. Reading the history of these first attempts to place a net-work of cables at the bottom of the ocean fifteen and twenty years ago, is a good deal like reading the old stories of the early voyages of discovery. There are difficulties and disasters peculiar to every attempt, and the grand result is that, one way or another, they were overcome, or else they suggested such modifications that their recurrence was avoided, and an accident to a well-manufactured cable no longer constitutes a loss.

The first Atlantic cable failed principally on account of imperfect manufacture, in a great measure arising from undue haste and urgency, but largely owing to insufficient experience. The cable was not tested under water, for fear of rusting the small steel wires of the external covering, and small wires have never since been used; large wires, the larger the better, is now a principle. The copper was not all good. It had often been coiled and uncoiled, and had been exposed to the strong heat of the sun, and to many changes of temperature. Any of these conditions would nowadays be regarded as enough to condemn the most carefully-manufactured cable.

The Red Sea and Indian cables are said to have been imperfectly manufactured and laid too taut, but they were not tested under water from the time of manufacture until they were placed at the bottom of the sea, and this one grand omission, largely due to inexperience, is enough, without the recriminatory points, to condemn to loss and failure any cable whatever.

The cables laid from Cagliari to Malta and Malta to Corfu are said to have failed from imperfect manufacture. One experienced gentleman in his evidence said these cables were "such as nobody should have laid in deep water." It is sufficient at present to know that they have failed from neglect or inexperience, and that they, among other failures, have established the principles which have since insured success.

The want of constant supervision by engineers, exclusively in the interests of the purchasers of the cable, has been a great cause of defective cables. There may often be minute defects in the core itself, or a slightly defective splice which may reduce the electrical condition of a comparatively short length; this may easily be raised above the average standard required by the contract, by the next length being more carefully manufactured. These minute defects must, however, kill the cable in more or less time, and the principle is established that every inch should be tested in course of manufacture, and rejected if there is any irregularity of condition to cause suspicion. There should be constant supervision, and a record of all the tests kept for the purchasers of the cable from the commencement of the contract to its final completion, and continued ever afterward by the purchasers.

The principal sources of injury to cables are—first, moving water, either currents or tides, chafing the cables upon rocks or shingle. Experience has given many costly lessons of the effect of moving water.

Ten years ago it was generally believed that water had very little motion below 50 fathoms, and 100 fathoms was considered a point of great safety. We now know that there are exceptional localities where there is motion in the water at a depth of 500 fathoms. The Falmouth cable was chafed and destroyed at this depth from this cause. The Channel Islands cable was also destroyed from the same cause. The first cable ever manufactured with due regard to the principle of careful supervision, testing under water, and being retained quietly in

that condition until it was laid, was the Malta and Alexandria cable, laid in 1861. This cable was submerged in too shallow water, for many miles in less depth than 20 fathoms; the result was the frequent recurrence of fracture from being rolled about by the surf, and yet this cable was only finally abandoned last year; not because it could not be kept in repair, but because it was too expensive to keep in order. These and many other examples have established the principle that no cable should be laid without first obtaining an accurate survey of the approach to the coast and landing-places, with accurate soundings over the intended route, and as much knowledge as possible of the nature of the bottom. Currents and anchorage should be avoided, and, where that is impossible, the heaviest cable that can be laid should be provided. Heavy cables should be laid out to depths of 400 fathoms, where there are tide-ways. Where a current exists, a position should be sought for as far removed from it as possible. A great cause of injury to cables is the corrosion of the external wires, caused by moving water or marine vegetation, etc., and this has established the general practice of covering the external wires with tarred yarn saturated with a mixture of pitch and silica. There is still great room for improvement upon the present method of protecting the external covering of cables, and I commend it to the further careful study of telegraph-engineers as a subject of vital importance.

Another enemy of submarine cables is the *teredo*[1] of all kinds; there is one kind which has proved destructive by boring through the core, but that has only occurred in shallow water; there is another kind which destroys the hemp in a few months, and is then satisfied to fix itself upon the gutta-percha and remain there. Cables have been recovered from depths of 1,200 fathoms with all the hemp eaten away, and the core pitted with these marine animals. The recovery is then only possible by the strength of the external wires.

All the experience we have points to the value of protection, first, of the core, then of the external covering, and, if those responsible for the safety and maintenance of submarine cables could be allowed to dictate the most desirable conditions of safety, they would select, besides the strongest possible cable to be manufactured, and laid with extreme care, a depth of water of about 500 fathoms, and a bottom of sand or mud; but, as this cannot always be secured, nothing should be omitted in the direction of strength and quality.

Lightning is still another source of injury to cables; this is, however, so readily guarded against that we no longer hear of injury from this cause: it is said to have destroyed three cables. Mr. Siemens produced before the committee a piece of the core of the Corfu cable injured by lightning; the land-line had been struck, and, from the absence of any lightning-guards, the cable was damaged. Mr. Preece described the Jersey cable as having been destroyed by lightning. Mr.

[1] *See* article, in this number, on the "Borers of the Sea."

Fleeming Jenkin has seen a fault 18 inches long due to this cause, and it is asserted that the same cause destroyed the Toulon-Algiers cable, which was connected to the land-lines without lightning-guards.

We are every now and then startled by the announcement that light cables are to be preferred to the present iron-clad type, and the object of this investigation has been to discover what data there are to justify any preference to one form of cable over another. I have said already that the committee called attention to the remarkable fact that, in almost all cases, small cables have been found liable to mishaps, while the heavier the cable the greater had been its durability.

Mr. Newall, in his evidence, said that the hemp-covered cable which he attempted to lay in 1859, between Candia and Egypt, had the hemp eaten off by the *teredo* in a very short time, and it was too weak to recover for repairing. The same firm laid an unprotected core from Varna to the Crimea, and it lasted until the winter set in; it is frequently said that it was cut by order of the French commander-in-chief, but there is no proof of this, and I am not disposed to believe it. Mr. Woodehouse, the engineer who laid this core, said in his evidence he "should not advise anybody to lay so light a cable across the Atlantic, because so small a strain would break it. If it is once safe at the bottom, perhaps it may rest." Mr. Newall said he thought it folly to lay any thing excepting unprotected core. Consistently with this conviction, he laid in 1869 several lines of unprotected India-rubber core, connecting the Grecian islands with the main-land; they were protected only near the shore. The sea is quiet and tideless in those parts; no better spot could be wished for the experiment, yet they every one of them gave out within two years.

The Red Sea cable, covered externally with light wires, and unprotected with bituminous compound, was so rusted in a short time that it could not be lifted for repairs.

Notwithstanding Mr. Newall's partiality for light cables, he suggests at the close of his evidence what I assume he would consider the most perfect form of cable. He would cover the copper with India-rubber, protect this core with steel wires vulcanized, the whole then passed through heat; thus insulating all the wires, he would make the cable in one length, and have no joints. Mr. Fleeming Jenkin, in his report to the International Exhibition of 1862, says:

"So long as the iron wires lasted, the cables frequently continued to work in spite of faults, but sooner or later the iron wires of all these light cables rusted away in parts; so soon as this took place they one and all broke up into short sections; this fact has been observed in depths of 100 fathoms;" the reasons were not obvious to Mr. Jenkin, but he says: "Meanwhile the use of large iron wire seems a sure guarantee against this danger, for as yet no cable covered with wire of the large gauges has ever parted in the manner described. The difficulty is, to find a permanent material which shall retain its strength and continue to afford protection after the cable is laid."

Every word of this can be written at the present moment, that is, ten years later, with exactly the same significance. All cables which have been manufactured and laid upon the principles which were established in 1859 are yet in good working order, and every divergence from these principles has been at best but a costly experiment or utter failure. There is no instance yet of a well-manufactured heavy cable breaking or giving out in deep water after it has been carefully laid free from defects; but there may be much due to the external covering keeping it quiet; there has assuredly been a great deal due to the external covering in the successful submerging, and there is no experience whatever to justify the assumption that an unprotected core would last, even if laid.

It has been urged that an iron-covered cable, suspended from one point to another, gradually becomes weaker, that rust and marine growth or deposit accumulate and break the cable with their weight; but I do not know of any instance in support of the assumption, nor is it at all certain that a simple unprotected core would exist for any length of time, or be in any way better adapted for the supposed conditions. Mr. Latimer Clark, in his evidence, says: "You want a certain degree of weight to enable your cable to sink steadily to the bottom, especially when it has to fall into hollows and cavities, and not lie loosely across elevations."

Again, it is urged that experiments with light cables have been tried in factories or sheds, and the result proves that there are many advantages in their favor; but I am of opinion that no experiments which can be made on shore will sufficiently resemble the exigencies which may occur over a period of several days and nights at sea in storms and darkness, and still less will they prove their fitness for the unknown conditions which may exist at great ocean-depths. I desire to write with great respect for the opinions of the talented men who urge the adoption of light cables; it is my special duty to weigh well and without prejudice all they have to advance; but I think a careful investigation into the experience and practice of the last twenty years establishes conclusively that all light cables have been short-lived, and that all heavy cables have continued working, often under most adverse conditions. It is my own opinion, and I am authorized to say that it is also the opinion of my friend Captain Halpin, who has laid all the cables from Suez to Australia, besides the French Atlantic cable (11,000 miles), and has also recovered and repaired cables from a great variety of depths, that a cable should be as heavy as it can be laid with safety, and admit of being recovered in case of accident. Multiply every precaution which shall increase the strength and keep that strength intact as long as possible.

The best form of light cable I have seen is the copper-covered core invented by Mr. Siemens (No. 8). I should have anticipated that, if any light cable could have been successful, this one would have met

all the conditions, excepting that of extreme cheapness, but it has not been so uniformly successful as the heavy iron-clad cables. The very light cable invented by Mr. Varley (No. 21) admits of being laid by having the strain taken off the core by the two hempen strands, the core itself being the third strand of the cable. As a light cable, to be manufactured in a great hurry, and laid to meet some emergency, it has a good deal of merit, but for a deep-sea cable I am of opinion that it would be found too incomplete and unfinished, and that difficulties would be experienced in laying which are not at once foreseen, and that there would be no durability even if successfully laid.

Every day of my experience in watching over the permanence of the 10,000 miles of cable under my care, confirms me in the opinion that too great caution and vigilance cannot be exercised in the making and laying a thread which is to be removed from all human vision forever, and designed to earn dividends by continuing a perfect conductor of electricity. Upward of 30,000 miles of cable have been laid since the report of the committee was printed, eleven years ago, and much experience has been gained of the exigencies incidental to submerging, buoying, grappling, and repairing; but no fact has resulted from all that experience which has established that any one precaution recommended in the report has been superfluous, whereas much has occurred, which I will not particularize, proving that any attempt to disregard any single precaution has resulted in great pecuniary loss or utter failure.

We have many reasons to confirm the belief that a submarine cable, manufactured and laid with strict attention to all known principles, may be regarded as a substantial property, likely to last for any length of time; for there is no evidence whatever upon record which shows any decay of the insulating medium or copper conductor of a well-manufactured cable, i. e., there is no decay inherent in the nature of a cable; all deterioration is external; nor is there any experience whatever to establish that this insulated copper wire will enjoy any durability if unprotected with an external covering.

A light cable or unprotected core must therefore be regarded at best as an experiment, with the chances against the successful laying, and still more against its existing as a permanent property.

I have written enough to illustrate that the present submarine cable is not a haphazard idea, but one which has grown out of many failures and thousands of experiments; all the principles of manufacture and laying down have been established by great anxiety and reflection on the part of the able men who gave their energies to this kind of enterprise prior to 1865. We who have come upon the stage since that date have only discovered that we may not neglect one of all the known principles, but elaborate every one of them, and even then the duty of laying and maintaining this class of property has enough of risks and anxieties to make one heartily dislike any experi-

ment which can only be advocated for the sake of cheapness in the first cost. I believe this economy would be at the expense of security, and that the cable of the future will be even heavier, more perfect, and more costly, than the cable of the present day.—*Abstract of Address before the Statistical Society.*

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

X.—*The Class-Bias.*

MANY years ago, a solicitor, sitting by me at dinner, complained bitterly of the injury which the then lately-established County Courts were doing his profession. He enlarged on the topic in a way implying that he expected me to agree with him in therefore condemning them. So incapable was he of going beyond the professional point of view, that what he regarded as a grievance he thought I also ought to regard as a grievance: oblivious of the fact that the more economical administration of justice, of which his lamentation gave me proof, was to me, not being a lawyer, matter for rejoicing.

The bias thus exemplified is a bias by which nearly all have their opinions warped. Naval officers disclose the unhesitating belief that we are in imminent danger because the cry for more fighting-ships and more sailors has not been met to their satisfaction. The debates on the purchase-system proved how strong was the conviction of military men that our national safety depended on the maintenance of an army-organization like that in which they were brought up, and had attained their respective ranks. Clerical opposition to the repeal of the Corn-laws showed how completely that view which Christian ministers might have been expected to take, was shut out by a view more congruous with their interests and alliances. In all classes and subclasses it is the same. Hear the murmurs uttered when, because of the Queen's absence, there is less expenditure in entertainments and the so-called gayeties of the season, and you perceive that London traders think the nation suffers if the consumption of superfluities is checked. Study the pending controversy about coöperative stores *versus* retail shops, and you find the shopkeeping mind possessed by the idea that society commits a wrong if it deserts shops and goes to stores—is quite unconscious that the present distributing system rightly exists only as a means of economically and conveniently supplying consumers, and must yield to another system if that should prove more economical and convenient. Similarly with the other trading bodies, general and special—similarly with the merchants who opposed the repeal of the Navigation Laws; similarly with the Coventry weavers, who like free-trade in all things save ribbons.

The class-bias, like the bias of patriotism, is a reflex egoism; and, like it, has its uses and abuses. As the strong feelings enlisted on behalf of one's nation cause that enthusiastic coöperation by which its integrity is maintained in presence of other nations, severally tending to spread and subjugate their neighbors; so the *esprit de corps*, more or less manifest in each specialized part of the body politic, prompts measures to preserve the integrity of that part in opposition to other parts, all more or less antagonistic. The egoism of individuals becomes an egoism of the class they form; and, besides the separate efforts, generates a joint effort to get an undue share of the aggregate proceeds of social activity. The aggressive tendency of each class, so produced, has to be balanced by like aggressive tendencies of other classes. The class-feelings do, in short, develop one another; and the respective organizations in which they embody themselves develop one another. Large classes of the community, marked off by rank, and sub-classes marked off by special occupations, everywhere form their defensive combinations, and set up organs advocating their interests; and the reason assigned is in all cases the same—the need for self-defence.

Along with the good which a society derives from this self-asserting and self-preserving action, by which each division and subdivision keeps itself strong enough for its functions, there goes, among other evils, this which we are considering—the aptness to contemplate all social actions in their bearings on class-interests, and the resulting inability to estimate rightly their effects on the society as a whole. The habit of thought produced perverts not merely the judgments on questions which directly touch class-welfare, but it perverts the judgments on multitudinous questions which touch class-welfare very indirectly, if at all. It fosters an adapted theory of social relations of every kind, with sentiments to fit the theory; and a characteristic stamp is given to the beliefs on public matters in general. Take an instance:

Whatever its technical ownership may be, Hyde Park is open for the public benefit: no title to special benefit is producible by those who ride and drive. It happens, however, that those who ride and drive make large use of it daily; and extensive tracts of it have been laid out for their convenience: the tracts for equestrians having been from time to time increased. Of people without carriages and horses, a few, mostly of the kind who lead easy lives, use Hyde Park frequently as a promenade. Meanwhile, by the great mass of Londoners, too busy to go so far, it is scarcely ever visited: their share of the general benefit is scarcely appreciable. And now what do the few who have a constant and almost exclusive use of it think about the occasional use of it by the many? They are angry when, at long intervals, even a small portion of it, qute distant from their haunts, is occupied for a few hours in ways disagreeable to them—nay, even when such temporary occupation is on a day during which Rotten

Row is nearly vacant, and the drives not one-third filled. In this, any one unconcerned may see the influence of the class-bias. But he will have an inadequate conception of its distorting power unless he turns to some letters from members of the ruling class published in the *Times* in November last, when the question of the Park Rules was being agitated. One writer, signing himself "A Liberal M. P.," expressing his disgust at certain addresses he heard, proposed, if others would join him, to give the offensive speakers punishment by force of fists; and then, on a subsequent day, another legislator, similarly moved, writes:

> "If 'M. P.' is in earnest in his desire to get some honest men together to take the law into their own hands, I can promise him a pretty good backing from those who are not afraid to take all the consequences.
>
> "I am, sir, your obedient servant, AN EX-M. P."

And thus we find class-feeling extinguishing rational political thinking so completely that, wonderful to relate, two law-makers propose to support the law by breaking the law!

In larger ways we have of late seen the class-bias doing the same thing—causing contempt for those principles of constitutional government slowly and laboriously established, and prompting a return to barbaric forms of government. Read the debate respecting the payment of Governor Eyre's expenses, and study the division-lists, and you see that acts which, according to the Lord Chief-Justice, "have brought reproach not only on those who were parties to them, but on the very name of England," can, nevertheless, find numerous defenders among men whose class-positions, military, naval, official, etc., make them love power and detest resistance. Nay, more, by raising an Eyre-Testimonial Fund, and in other ways, there was shown a deliberate approval of acts which needlessly suspended orderly government and substituted unrestrained despotism. There was shown a deliberate ignoring of the essential question raised, which was—whether an executive head might, at will, set aside all those forms of administration by which men's lives and liberties are guarded against tyranny.

More recently, this same class-bias has been shown by the protest made when Mr. Cowan was dismissed for executing the Kooka rioters who had surrendered. The Indian Government, having inquired into the particulars, found that this killing of many men, without form of law and contrary to orders, could not be defended on the plea of pressing danger; and, finding this, it ceased to employ the officer who had committed so astounding a deed, and removed to another province the superior officer who had approved of the deed. Not excessive punishment, one would say. Some might contend that extreme mildness was shown in thus inflicting no greater evil than is inflicted on a laborer when he does not execute his work properly. But now mark what is thought by one who gives utterance to the bias of the govern-

ing classes, intensified by life in India. In a letter published in the *Times* of May 15, 1872, the late Sir Donald McLeod writes concerning this dismissal and removal:

"All the information that reaches me tends to prove that a severe blow has been given to all chance of vigorous or independent action in future, when emergencies may arise. The whole service appears to have been astonished and appalled by the mode in which the officers have been dealt with."

That we may see clearly what amazing perversions of sentiment and idea are caused by contemplating actions from class points of view, let us turn from this feeling of sympathy with Mr. Cowan to the feeling of detestation shown by members of the same class in England toward a man who kills a fox that destroys his poultry. Here is a paragraph from a recent paper:

"Five poisoned foxes have been found in the neighborhood of Penzance, and there is consequently great indignation among the western sportsmen. A reward of £20 has been offered for information that shall lead to the conviction of the poisoner."

So that wholesale homicide, condemned alike by religion, by equity, by law, is approved, and the mildest punishment of it blamed; while vulpicide, committed in defence of property, and condemned neither by religion, nor by equity, nor by any law save that of sportsmen, excites an anger that cries aloud for positive penalties!

I need not further illustrate the more special distortions of sociological belief which result from the class-bias. They may be detected in the conversations over every table, and in the articles appearing in every party-journal or professional publication. The effects here most worthy of our attention are the general effects—the effects produced on the minds of the upper and lower classes. Let us observe how greatly the sentiments and ideas generated by their respective social positions pervert the conceptions of employers and employed. We will deal with the employed first.

As before shown, mere associations of ideas, especially when joined with emotions, affect our beliefs, not simply without reason, but in spite of reason, causing us, for instance, to think there is something intrinsically repugnant in a place where many painful experiences have been received, and something intrinsically charming in a scene connected with many past delights. The liability to such perversions of judgment is greatest where *persons* are the objects with which pleasures and pains are habitually associated. One who has often been, even unintentionally, a cause of gratification, is favorably judged; and an unfavorable judgment is apt to be formed of one who, even involuntarily, has often inflicted sufferings. Hence, where there are social antagonisms, arises the universal tendency to blame the *individuals*, and to hold them responsible for the *system*.

It is thus with the conceptions the working-classes frame of those by whom they are immediately employed, and of those who fill the higher social positions. Feeling keenly what they have to bear, and tracing sundry real grievances to men who buy their labor, and men who are most influential in making the laws, artisans and rustics conclude that, considered individually and in combination, those above them are personally bad—selfish, or tyrannical, in special degrees. It never occurs to them that the evils they complain of result from the average human nature of our age. And yet, were it not for the class-bias, they would see, in their dealings with one another, plenty of proofs that the injustices they suffer are certainly not greater, and possibly less, than they would be were the higher social functions discharged by individuals taken from among themselves. The simple fact, notorious enough, that working-men, who save money and become masters, are not more considerate than usual toward those they employ, but often the contrary, might alone convince them of this. On all sides there is ample evidence having kindred meaning. Let them inquire about the life in every kitchen where there are several servants, and they will find quarrels about supremacy, tyrannies over juniors who are made to do more than their proper work, throwings of blame from one to another, and the many forms of misconduct caused by want of right feeling; and very often the evils growing up in one of these small groups are greater than the evils pervading society at large. The doings in workshops, too, illustrate in various ways the ill-treatment of artisans by one another. Hiding the tools and spoiling the work of those who do not conform to their unreasonable customs, prove how little individual freedom is respected among them. And still more conspicuously is this proved by the internal governments of their trade-combinations. Not to dwell on the occasional killing of men among them, who assert their rights to sell their labor as they please, or on the frequent acts of violence and intimidation committed by those on strike against those who undertake the work they have refused, it suffices to cite the despotism exercised by trades-union officers. The daily acts of these make it manifest that the ruling organizations formed by working-men inflict on them grievances as great as, if not greater than, those which the organization of society at large inflicts. When the heads of a combination he has joined forbid a collier to work more than three days in a week—when he is limited to a certain "get" in that space of time—when he dares not accept from his employer an increasing bonus for every extra day he works—when, as a reason for declining, he says that he should be made miserable by his comrades, and that even his wife would not be spoken to; it becomes clear that he and the rest have made for themselves a tyranny worse than the tyrannies complained of. Did he look at the facts, apart from class-bias, the skilful artisan, who in a given time can do more than his fellows, but who dares not do it be-

cause he would be "sent to Coventry" by them, and who consequently cannot reap the benefit of his superior powers, would see that he is thus aggressed upon by his fellows more seriously than by acts of Parliament or combinations of capitalists. And he would further see that the sentiment of justice in his own class is certainly not greater than in the classes he thinks so unjust.

The feeling which thus warps working-men's conceptions, at the same time prevents them from seeing that each of their unions is selfishly aiming to benefit at the expense of the industrial population at large. When a combination of carpenters or of engineers makes rules limiting the number of apprentices admitted, with the view of maintaining the rate of wages paid to its members—when it thus tacitly says to every applicant beyond the number allowed, "Go and apprentice yourself elsewhere;" it is indirectly saying to all other bodies of artisans, "You may have your wages lowered by increasing your numbers, but we will not." And when the other bodies of artisans severally do the like, the general result is that the incorporated workers, of all orders, say to the surplus sons of workers who want to find occupations, "We will none of us let our masters employ you." Thus each trade, in its eagerness for self-protection, is regardless of other trades, and sacrifices numbers among the rising generation of the artisan class. Nor is it thus only that the interest of each class of artisans is pursued to the detriment of the artisan-class in general. I do not refer to the way in which, when bricklayers strike, they throw out of employment the laborers who attend them, or to the way in which the colliers now on strike have forced idleness on the iron-workers; but I refer to the way in which the course taken by any one set of operatives, to get higher wages, is taken regardless of the fact that an eventual rise in the price of the commodity produced is a disadvantage to all other operatives. The class-bias, fostering the belief that the question in each case is entirely one between employer and employed, between capital and labor, shuts out the truth that the interests of all consumers are involved, and that the immense majority of consumers belong to the working-classes themselves. If the consumers are named, such of them only are remembered as belong to the wealthier classes, who, it is thought, can well afford to pay higher prices. Listen to a passage from Mr. George Potter's paper, read at the late Leeds Congress:

"The consumer, in fact, in so high a civilization, so arrogant a luxuriousness, and so impatient an expectancy as characterize him in our land and age, is ever ready to take the alarm and to pour out the phials of his wrath upon those whom he merely suspects of taking a course which may keep a feather out of his bed, a spice out of his dish, or a coal out of his fire; and, unfortunately for the chances of fairness, the weight of his anger seldom falls upon the capitalists, but is most certain to come crushing down upon the lowly laborer, who has dared to stand upon his own right and independence."

From which it might be supposed that all skilled and unskilled artisans and farm-laborers, with their wives and children, live upon air—need no food, no clothing, no furniture, no houses, and are therefore unaffected by enhanced prices of commodities. However fully prepared for the distorting effects of class-bias, one would hardly have expected effects so great. One would have thought it manifest, even to an extreme partisan of trades-unions, that a strike which makes coal as dear again, affects, in a relatively small degree, the thousands of rich consumers above described, and is very keenly felt by the millions of poor consumers to whom, in winter, the outlay for coal is a serious item of expenditure. One would have thought that a truth, so obvious in this case, would be recognized throughout—the truth that, with nearly all products of industry, the evil caused by a rise of price falls more heavily on the vast numbers who work for wages than on the small numbers who have moderate incomes or large incomes.

Were not their judgments warped by the class-bias, working-men might be more pervious to the truth that better forms of industrial organization would grow up and extinguish this which they regard as oppressive, were such better forms practicable. And they might see that the impracticability of better forms results from the imperfections of existing human nature, moral and intellectual. If the workers in any business could so combine and govern themselves that the share of profit coming to them as workers was greater than now, while the interest on the capital employed was less than now; and if they could at the same time sell the articles produced at lower rates than like articles produced in businesses managed as at present, then, manifestly, businesses managed as at present would go to the wall. That they do not go to the wall—that such better industrial organizations do not replace them, implies that the natures of working-men themselves are not good enough; or, at least, that there are not many of them good enough. Happily, to some extent, organizations of a superior type are becoming possible: here and there they have achieved encouraging successes. But, speaking generally, the masses are neither sufficiently provident, nor sufficiently conscientious, nor sufficiently intelligent. Consider the evidence.

That they are not provident enough they show both by wasting their higher wages when they get them, and by neglecting such opportunities as occur of entering into modified forms of coöperative industry. When the Gloucester Wagon Company was formed, it was decided to reserve a thousand of its shares, of ten pounds each, for the workmen employed; and to suit them it was arranged that the calls of a pound each should be at intervals of three months. As many of the men earned £2 10*s.* per week, in a locality where living is not costly, it was considered that the taking up of shares in this manner would be quite practicable. All the circumstances were at the outset such as to promise that prosperity which the company has achieved.

The chairman is no less remarkable for his skill in the conduct of large undertakings than for that sympathy with the working-classes which led him to adopt this course. The manager had been himself a working-man; and so fully possessed the confidence of working-men that many migrated with him from the Midland counties when the company was formed. Further, the manager entered heartily into the plan—telling me himself that he had rejoiced over the founding of a concern in which those employed would have an interest. His hopes, however, and those of the chairman, were disappointed. After the lapse of a year, not one of the thousand shares was taken up; and they were then distributed among the proprietors. Doubtless, there have been in other cases more encouraging results. But this case is one added to others which show that the proportion of working-men adequately provident is not great enough to permit an extensive growth of better industrial organizations.

Again, the success of industrial organizations, higher in type, requires in the members a nicer sense of justice than is at present general. Closer coöperation implies greater mutual trust; and greater mutual trust is not possible without more respect for one another's claims. When we find that in sick-clubs it is not uncommon for members to continue receiving aid when they are able to work, so that spies have to be set to check them; while, on the other hand, those who administer the funds often cause insolvency by embezzling them; we cannot avoid the inference that want of conscientiousness must very generally prevent the effective union of workers under no regulation but their own. When, among skilled laborers, we find a certain rate per hour demanded, because less "did not suffice for their natural wants," though the unskilled laborers working under them were receiving little more than half the rate per hour, and were kept out of the skilled class by stringent rules, we do not discover a moral sense so much above that shown by employers as to promise success for industrial combinations superior to our present ones. While workmen think themselves justified in combining to sell their labor only on certain terms, but think masters not justified in combining to buy only on certain terms, they show a conception of equity not high enough to make practicable a form of coöperation requiring that each shall recognize the claims of others as fully as his own. One pervading misconception of justice betrayed by them would alone suffice to cause failure—the misconception, namely, that justice requires an equal sharing of benefits among producers, instead of requiring, as it does, equal freedom to make the best of their faculties. The general policy of trades-unionism, tending everywhere to restrain the superior from profiting by his superiority lest the inferior should be disadvantaged, is a policy which, acted out in any industrial combinations, must make them incapable of competing with combinations based on the principle that benefit gained shall be proportioned to faculty put forth.

Thus, as acting on the employed in general, the class-bias obscures the truth, otherwise not easy to see, that the existing type of industrial organization, like the existing type of political organization, is about as good as existing human nature allows. The evils there are in it are nothing but the evils brought round on men by their own imperfections. The relation of master and workman has to be tolerated, because, for the time being, no other will answer as well. Looked at apart from special interests, this organization of industry we now see around us must be considered as one in which the cost of regulation, though not so great as it once was, is still excessive. In any industrial combination there must be a regulating agency. That regulating agency, whatever its nature, must be paid for—must involve a deduction from the total proceeds of the labor regulated. The present system is one under which the share of the total proceeds that goes to pay for regulation is considerable; and, under better systems to be expected hereafter, there will doubtless be a decrease in the cost of regulation. But, for the present, our comparatively-costly system has the justification that it alone succeeds. Regulation is costly because the men to be regulated are defective. With decrease of their defects will come economy of regulation, and consequently greater shares of profit to themselves.

Let me not be misunderstood. The foregoing criticism does not imply that operatives have no grievances to complain of; nor does it imply that trade-combinations and strikes are without adequate justifications. It is quite possible to hold that when, instead of devouring their captured enemies, men made slaves of them, the change was a step in advance; and to hold that this slavery, though absolutely bad, was relatively good—was the best thing practicable for the time being. It is quite possible also to hold that when slavery gave place to a serfdom under which certain personal rights were recognized, the new arrangement, though in the abstract an inequitable one, was more equitable than the old, and constituted as great an amelioration as men's natures then permitted. It is quite possible to hold that when, instead of serfs, there came freemen working for wages, but held as a class in extreme subordination, this modified relation of employers and employed, though bad, was as good a one as was then practicable. And so it may be held that at the present time, though the form of industrial government entails serious evils, those evils, much less than the evils of past times, are as small as the average human nature allows—are not due to any special injustice of the employing class, and can be remedied only as fast as men in general advance. On the other hand, while contending that the policy of trades-unions, and the actions of men on strike, manifest an injustice as great as that shown by the employing classes, it is quite consistent to admit, and even to assert, that the evil acts of trade-combinations are the unavoidable accompaniments of a needful self-defence. Selfishness

on the one side, resisting selfishness on the other, inevitably commits sins akin to those it complains of—cannot effectually check harsh dealings without itself using harsh measures. Further, it may be fully admitted that the evils of working-class combinations, great as they are, are accompanied by certain benefits, and will perhaps hereafter be followed by greater benefits—are evils accompanying the transition to better arrangements.

Here my purpose is neither to condemn nor to applaud the ideas and actions of the employed in their dealings with employers; but simply to point out how the class-bias warps working-men's judgments of social relations—makes it difficult for working-men to see that our existing industrial system is a product of existing human nature, and can be improved only as fast as human nature improves.

The ruling and employing classes display an equally-strong bias of the opposite kind. From their point of view, the behavior of their poorer fellow-citizens throughout these struggles appears uniformly blamable. That they experience from a strike inconvenience, more or less considerable, sufficiently proves to them that the strike must be wrong. They think there is something intolerable in this independence which leads to refusals to work except at higher wages or for shorter times. That the many should be so reckless of the welfare of the few, seems to the few a grievance not to be endured. Though Mr. George Potter, as shown above, wrongly speaks of the consumer as though he were always rich, instead of being, in nine cases out of ten, poor; yet he rightly describes the rich consumer as indignant when operatives dare to take a course which threatens to raise the prices of necessaries and make luxuries more costly. This feeling, often betrayed in private, exhibited itself in public on the occasion of the late strike among the gas-stokers; when there were uttered proposals that acts entailing so much inconvenience should be put down with a strong hand. And the same spirit was shown in that straining of the law which brought on the men the punishment for conspiracy, instead of the punishment for breach of contract; which was well deserved, and would have been quite sufficient.

This mental attitude of the employing classes is daily shown by the criticisms passed on servants. Read "The Greatest Plague in Life," or listen to the complaints of every housewife, and you see that the minds of masters and mistresses are so much occupied with their own interests as to leave little room for the interests of the men and maids in their service. The very title, "The Greatest Plague in Life," implies that the only life worthy of notice is the life to which servants minister; and there is an entire unconsciousness that a book with the same title, written by a servant about masters and mistresses, might be filled with equally-severe criticisms and grievances far more serious. The increasing independence of servants is enlarged upon as a change

greatly to be lamented. There is no recognition of the fact that this increasing independence implies an increasing prosperity of the classes from which servants come; and that this amelioration in the condition of the many is a good far greater than the evil entailed on the few. It is not perceived that if servants, being in great demand and easily able to get places, will no longer submit to restrictions, say about dress, like those of past times, the change is part of the progress toward a social state which, if apparently not so convenient for the small regulating classes, implies an elevation of the large regulated classes.

The feeling shown by the rich, in their thoughts about and dealings with the poor, is, in truth, but a mitigated form of the feeling which owners of serfs and owners of slaves displayed. In early times bondsmen were treated as though they existed simply for the benefit of their owners; and down to the present time the belief pervading the select ranks (not indeed expressed, but clearly enough implied) is, that the convenience of the select is the first consideration, and the welfare of the masses a secondary consideration. Just as an Old-English thane would have been astonished if told that the only justification for his existence as an owner of thralls was, that the lives of his thralls were on the whole better preserved and more comfortable than they would be did he not own them; so, now, it will astonish the dominant classes to assert that their only legitimate *raison d'être* is, that by their instrumentality as regulators the lives of the people are, on the average, made more satisfactory than they would otherwise be. And yet, looked at apart from class-bias, this is surely an undeniable truth. Ethically considered, there has never been any warrant for the subjection of the many to the few, except that it has furthered the welfare of the many; and, at the present time, furtherance of the welfare of the many is the only warrant for that degree of class-subordination which continues. The existing conception must be, in the end, entirely changed. Just as the old theory of political government has been so transformed that the ruling agent, instead of being owner of the nation, has come to be regarded as servant of the nation; so the old theory of industrial and social government has to undergo a transformation which will make the regulating classes feel, while duly pursuing their own interests, that their interests are secondary to the interests of the masses whose labors they direct.

While the bias of rulers and masters makes it difficult for them to conceive this, it also makes it difficult for them to conceive that a decline of class-power and a decrease of class-distinctions may be accompanied by improvement not only in the lives of the regulated classes, but in the lives of the regulating classes. The sentiments and ideas proper to the existing social organization prevent the rich from seeing that worry and weariness and disappointment result to them indirectly from this social system, apparently so conducive to their welfare. Yet, would they contemplate the past, they might find strong reasons for

suspecting as much. The baron of feudal days never imagined the possibility of social arrangements that would serve him far better than the arrangements he so strenuously upheld; nor did he see in the arrangements he upheld the causes of his many sufferings and discomforts. Had he been told that a noble might be much happier without a moated castle, having its keep and secret passages and dungeons for prisoners—that he might be more secure without drawbridge and portcullis, men-at-arms and sentinels—that he might be in less danger having no vassals or hired mercenaries—that he might be wealthier without possessing a single serf; he would have thought the statements absurd even to the extent of insanity. It would have been useless to argue that the *régime* seeming so advantageous to him entailed hardships of so many kinds—perpetual feuds with his neighbors, open attacks, surprises, betrayals, revenges by equals, treacheries by inferiors; the continual carrying of arms and wearing of armor; the perpetual quarrellings of servants and disputes among vassals; the coarse and unvaried food supplied by an unprosperous agriculture; a domestic discomfort such as no modern servant would tolerate; resulting in a wear and tear that brought life to a comparatively early close, if it was not violently cut short in battle or by murder. Yet what the class-bias of that time made it impossible for him to see, has become to his modern representative conspicuous enough. The peer of our day knows that he is better off without defensive appliances, and retainers, and serfs, than his predecessor was with them. His country-house is more secure than was an embattled tower; he is safer among his unarmed domestics than a feudal lord was when surrounded by armed guards; he is in less danger going about weaponless than was the mail-clad knight with lance and sword. Though he has no vassals to fight at his command, there is no suzerain who can call on him to sacrifice his life in a quarrel not his own; though he can compel no one to labor, the labors of freemen make him immensely more wealthy than was the ancient holder of bondsmen; and along with the loss of direct control over workers there has grown up an industrial system which supplies him with multitudinous conveniences and luxuries undreamt of by him who had workers at unchecked command.

May we not, then, suspect that, just as the dominant classes of ancient days were prevented by the feelings and ideas appropriate to the then-existing social state from seeing how much evil is brought on them, and how much better for them might be a social state in which their power was much less; so the dominant classes of the present day are disabled from seeing how the existing forms of class-subordination redound to their own injury, and how much happier may be their future representatives having social positions less prominent? Occasionally recognizing, though they do, certain indirect evils attending their supremacy, they do not see that by accumulation these indirect evils constitute a penalty which supremacy brings on them. Though

they repeat the trite reflection that riches fail to purchase content, they do not draw the inference that there must be something wrong in a system which thus deludes them. You hear it from time to time admitted that great wealth is a heavy burden: the life of a rich peer being described as made like the life of an attorney by the extent of his affairs. You observe, among those whose large means and various estates enable them to multiply their appliances to gratification, that every new appliance becomes an additional something to be looked after, and adds to the possibilities of vexation. Further, if you put together the open confessions and the tacit admissions, you find that, apart from these anxieties and annoyances, the kind of life which riches and honors bring is not a satisfactory life—its inside differs immensely from its outside. In candid moments the "social tread-mill" is complained of by those who nevertheless think themselves compelled to keep up its monotonous round. As every one may see, fashionable life is passed, not in being happy, but in playing at being happy. And yet the manifest corollary is not drawn by those engaged in this life.

To an outsider it is obvious that the benefits obtained by the regulative classes of our day, through the existing form of social organization, are full of disguised evils; and that this undue wealth which makes possible the passing of idle lives brings dissatisfactions in place of the satisfactions expected. Just as in feudal times the appliances for safety were the accompaniments to a social state that brought a more than equivalent danger; so, now, the excess of aids to pleasure among the rich is the accompaniment of a social state that brings a counterbalancing displeasure. The gratifications reached by those who make the pursuit of gratifications a business, dwindle to a minimum; while the trouble, and weariness, and vexation, and jealousy, and disappointment, rise to a maximum. That this is an inevitable result any one may see who studies the psychology of the matter. The pleasure-hunting life fails for the reason that it leaves large parts of the nature unexercised: it neglects the satisfactions gained by successful activity, and there is missing from it the serene consciousness of services rendered to others. Egoistic enjoyments, continuously pursued, pall, because the appetites for them are satiated in times much shorter than our waking lives give us: leaving times that are either empty or spent in efforts to get enjoyment after desire has ceased. They pall also from the want of that broad contrast which arises when a moiety of life is actively occupied. These negative causes of dissatisfaction are joined with the positive cause indicated—the absence of that content gained by successful achievement. One of the most massive and enduring gratifications is the sense of personal worth, ever afresh demonstrating itself to consciousness by effectual action; and an idle life is balked of its hopes partly because it lacks this. Lastly, the implied absence of altruistic activities, or of activi-

ties felt to be in some way serviceable to others, brings kindred evils —an absence of certain positive pleasures of a high order, not easily exhausted, and a further falling back on egoistic pleasures, again tending toward satiety. And all this, with its resulting weariness and discontent, we may trace to a social organization under which there comes to the regulating classes a share of produce great enough to make possible large accumulations that support useless descendants.

The bias of the wealthy in favor of arrangements apparently so conducive to their comforts and pleasures, while it shuts out the perception of these indirect penalties brought round on them by their seeming advantages, also shuts out the perception that there is any thing mean in being a useless consumer of things which others produce. Contrariwise, there still survives, though in a weaker form, the belief that it is honorable to do nothing but seek enjoyments, and relatively dishonorable to pass life in supplying others with the means to enjoyment. In this, as in other things, our temporary state brings a temporary standard of honor appropriate to it; and the accompanying sentiments and ideas exclude the conception of a state in which what is now thought admirable will be thought disgraceful. Yet it needs only, as before, to aid imagination by studying other times and other societies, remote in nature from our own, to see at least the possibility of this. When we contrast the feeling of the Feejeeans, among whom a man has a restless ambition to be acknowledged as a murderer, with the feeling among civilized races, who shrink with horror from a murderer, we get undeniable proof that men in one social state pride themselves in characters and deeds elsewhere held in the greatest detestation. Seeing which, we may infer that, just as the Feejeeans, believing in the honorableness of murder, are regarded by us with astonishment; so those of our own day who pride themselves in consuming much and producing nothing, and who care little for the well-being of their society so long as it supplies them with good dinners, soft beds, and pleasant lounging-places, may be regarded with astonishment by men of times to come, living under higher social forms. Nay, we may see not merely the possibility of such a change in sentiment, but the probability. Observe first the feeling still extant in China, where the honorableness of doing nothing, more strongly held than here, makes the wealthy wear their nails so long that they have to be tied back out of the way, and makes the ladies submit to prolonged tortures that their crushed feet may show their incapacity for work. Next, remember that, in generations gone by, both here and on the Continent, the disgracefulness of trade was an article of faith among the upper classes, maintained very strenuously. Now, mark how members of the landed class are going into business, and even sons of peers becoming professional men and merchants; and observe among the wealthy the feeling that men of their order have public duties to perform, and that the absolutely idle among them are blameworthy. Clearly, then,

we have grounds for inferring that, along with the progress to a regulative organization higher than the present, there will be a change of the kind indicated in the conception of honor. It will become a matter of wonder that there should ever have existed those who thought it admirable to enjoy without working, at the expense of others who worked without enjoying.

But the temporarily adapted mental state of the ruling and employing classes keeps out, more or less effectually, thoughts and feelings of these kinds. Habituated from childhood to the forms of subordination at present existing—regarding these as parts of a natural and permanent order—finding satisfaction in supremacy, and conveniences in the possession of authority; the regulators of all kinds remain unconscious that this system, made necessary as it is by the defects of existing human nature, brings round penalties on themselves as well as on those subordinate to them, and that its pervading theory of life is as mistaken as it is ignoble.

Enough has been said to show that from the class-bias arise further obstacles to right thinking in sociology. As a part of some general division of a community, and again as a part of some special subdivision, the citizen acquires adapted feelings and ideas which inevitably influence his conclusions about public affairs. They affect alike his conceptions of the past, his interpretations of the present, his anticipations of the future.

Members of the regulated classes, kept in relations more or less antagonistic with the classes regulating them, are thereby hindered from seeing the need for, and benefits of, this organization which seems the cause of their grievances; they are at the same time hindered from seeing the need for, and benefits of, the harsher forms of industrial regulation that existed during past times; and they are also hindered from seeing that the improved industrial organizations of the future can come only through improvements in their own natures. On the other hand, members of the regulating classes, while partially blinded to the facts that the defects of the working-classes are the defects of natures like their own placed under different conditions, and that the existing system is defensible, not for its convenience to themselves, but as being the best now practicable for the community at large, are also partially blinded to the vices of past social arrangements, and to the badness of those who in past social systems used class-power less mercifully than it is used now; while they have difficulty in seeing that the present social order, like past social orders, is but transitory, and that the regulating classes of the future may have, with diminished power, increased happiness.

Unfortunately for the Social Science, the class-bias, like the bias of patriotism, is in a degree needful for social preservation. It is like in this, too, that escape from its influence is often only effected by an

effort that carries belief to an opposite extreme—changing approval into a disapproval that is entire instead of partial. Hence, in the one case, as in the other, we must infer that the resulting obstacle to well-balanced conclusions can become less only as social evolution becomes greater.

THE BORERS OF THE SEA.

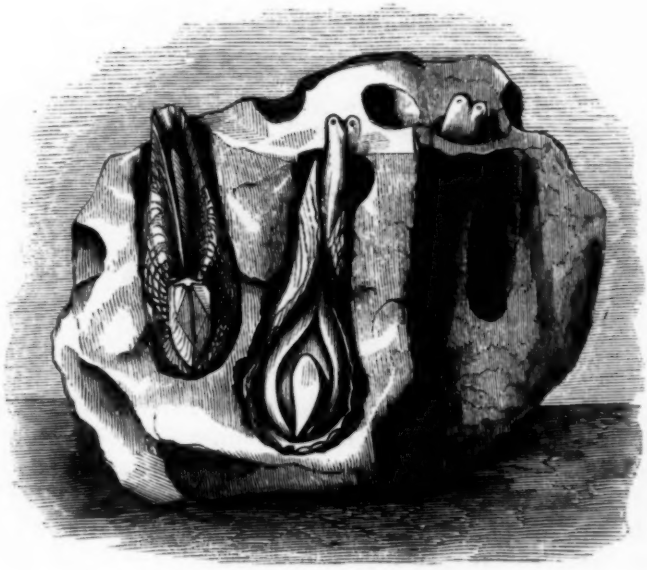
MANY stories are current as to how inventors have borrowed or stolen their ideas from Nature, and there has been much ingenious discussion as to whether hints thus appropriated are properly patentable. Boring is an example of natural processes that have been thus used by art, and it is remarkable that the lowest creatures are the most skilful mechanics in this particular. An eminent living inventor, who has made a fortune out of a patent auger, hit upon the method followed by the most successful insects which bore into hard wood. And so we are assured that the celebrated engineer Brunel, in constructing the Thames Tunnel, but imitated the shell-lined burrow of the *Teredo navalis*, or Ship-worm. This mollusk in shape resembles a worm, and surrounds itself with a shell open at both ends. From the mouth it can protrude its short foot, and the other extremity of its body; the "tail" is bifurcated, one prong being the inspirator and the other the expirator tube of the siphon which constitutes the animal's nutritive apparatus.

It has long been a subject of controversy among naturalists how the Ship-worm and other mollusks of the same family bore their way into the rocks and timbers which they penetrate. As regards the Pholades, for instance, Mr. Robertson, who kept these animals alive in their chalky burrows, and studied their habits with the closest attention, found that when burrowing they make a half-revolution of their shell to the right, and then back to the left, after the manner of a carpenter using a brad-awl. The Pholas is a bivalve, club-shaped, and the outer surface of its shell is covered with small teeth in curves, and resembling the face of a rasp. These teeth would naturally seem well suited for the purpose of boring, yet all naturalists are not agreed on this point. Thus, some hold that the animal secretes an acid solvent, which causes the material in which it is burrowing to decay. Then only is it that, securing itself with its sucker-like foot, it works itself from right to left, and *vice versa*, to widen the passage. But Mr. Gwynn Jeffreys, as stated in the December number of THE POPULAR SCIENCE MONTHLY, is of opinion that the foot, which he says is charged with siliceous particles, is the true boring apparatus of all the conchifera, and acts like the leaden wheel of the lapidary.

The history of the development of the *Teredo* is thus given by M.

de Quatrefages: "The larva, which is at first almost spherical and entirely covered with vibratile cilia, may be compared to a very minute hedgehog, in which every spine acts as a natatory organ. It swims in all directions with extreme agility, and this first state continues

FIG. 1.



ROCK PERFORATED BY PHOLADES.

about a day and a half. Toward the end of this time the external skin bursts, and, after being incrusted with calcareous salts, becomes a shell, which is at first oval, then triangular, and at last very nearly spherical. While the shell is being formed, the vibratile cilia disappear, but the little animal is not on that account condemned to inactivity. In proportion as the external cilia diminish, we observe that another equally ciliated organ becomes developed, which widens and extends in such a manner as to form a large collar or ruff margined with fringes. This new organ of locomotion may be entirely concealed within the shell, or may be extended from it, and acts in the manner of the paddle-wheel of a steamboat.

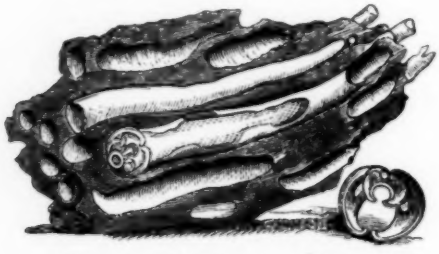
"By means of this apparatus the young larva continues to swim with as much facility as in its earlier age; but it now, moreover, acquires another organ, a sort of fleshy foot, which can be extended and contracted at will. It has also organs of hearing similar to those of several mollusks, and eyes analogous to those of certain annelids." The last metamorphosis is when the Teredo takes its worm-shape, and is ready to commence its boring operations.

The Teredo is supposed to have been originally a native of tropical

or semitropical seas, though now it is found in high latitudes. It does not appear to have been known to the Greeks or Romans, or at least its ravages in ancient times could not have been very great, else the unsheathed hulls of Greek and Roman vessels would have been perforated. The Pholas penetrates stone as well as wood, but the Teredo loves most to burrow into timber.

The damage done to submerged timbers by the Teredo is enormous.

FIG. 2.



TIMBER HONEY-COMBED BY THE TEREDO.

It once threatened the dikes of Holland with destruction. A portion of the pier at Yarmouth was so honey-combed with perforations that it might easily be crushed between the hands as though it were paper, the partition between the various tubes being in many places as thin as parchment. A piece broken off this pier, and measuring about 7 by 11 inches, weighed less than four ounces, including the shelly lining of the tubes. In the space of 40 days a piece of deal was fairly riddled by these borers, and Wood, in his "Natural History," gives an instance of their attacking a floating block of oak. This block had a large iron bolt passing through its centre, the rusting of which preserved the timber for a small space all around from the attacks of the borers. But all the block not so protected was honey-combed.

The Ship-worm always makes its perforations in the direction of the grain of the timber, except where a knot, or the shell of another Teredo, or hindrance of any kind is met with, and then it takes a turn according to circumstances. The animal begins to bore long before it has reached its full size, and it grows within the cavity which it makes. When taken out of the tube the Ship-worm is found to be a long, grayish-white animal, about one foot long and half an inch thick, with rounded head and forked tail. The Giant Teredo of Sumatra attains the length of six feet, and a diameter of three inches. This animal, however, differs from the Ship-worm in this, that it does not penetrate timber, but only burrows into the hardened mud of the sea-bed.

The use of copper-sheathing to protect ships from the Ship-worm is so well known that it need but be simply referred to here. It is not perhaps so generally known that, if timber be driven full of iron nails, the same object is attained. Another method of protecting wood-

work consists in forcing into its pores a solution of corrosive sublimate. The only objection to this method is its great cost. Quatrefages, however, asserts that one twenty-millionth part of corrosive sublimate is enough to destroy all the young Ship-worms in two hours. He, therefore, proposes that ships should be cleared of this fearful pest by being taken into a closed dock, into which a few handfuls of corrosive sublimate should be thrown and well mixed with the water. The salts of copper and lead have a similar effect, but do not act so instantaneously.

The Teredo does not perforate rock, but the Pholas acts an important part in bringing about geological changes, owing to his habit of boring rocks. There is no doubt that the chalk-cliffs of England are first tunnelled by the Pholades, and then gradually destroyed by the waves of the sea.

Of the Date-shell, another very interesting borer, Wood gives the following account: "It is truly a wonderful little shell. Some of the hardest stones and stoutest shells are found pierced by hundreds of these curious beings, which seem to have one prevailing instinct, namely, to bore their way through every thing. Onward, ever onward, seems to be the law of their existence, and most thoroughly do they carry it out. They care little for obstacles, and, if one of their own kind happens to cross their path, they quietly proceed with their work, and drive their tunnel completely through the body of their companion."

Of the *Saxicava rugosa*, another borer, Wood gives this description: "It is a flattish bivalve, symmetrical in shape when young, but oblong when old. It burrows as rapidly as the *Lithodomus*, and into rock of adamantine density. Sometimes it bores into corals, frequently into limestone, and often into shells, which it penetrates as deeply as the Date-shell. Some of the enormous stones employed in building the Plymouth Breakwater are now much wasted by the holes made in them by the *Saxicava*." Like the Date-shell, too, this animal runs its tunnels at every angle, and turns out of its course for no consideration whatever.

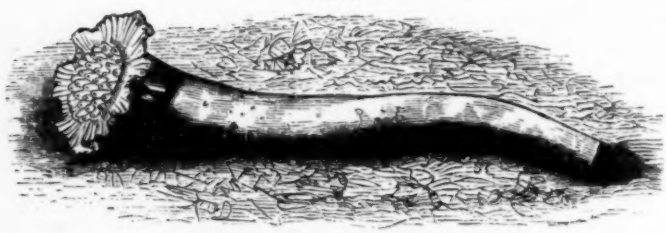
The Razor-shell makes a burrow in the sand, and there lives with its siphon, or recurved food-tube, appearing just above the mouth of the burrow. It may often be seen "spouting," or sending forth small jets of water from its hiding-place in the sand after the tide has retreated. On examining the spot cautiously—for the creature is somewhat shy—two round holes in the sand, answering to the two fringed openings of the Razor-shell's siphon, will be seen, resembling a key-hole, and each large enough to admit a common goose-quill. But, if the animal be approached rudely, or if the finger be placed on the openings, the mollusk disappears deep in the burrow. The Razor-shell is possessed of a very muscular "foot," as it is called, but it might as well be named a hand or a *tongue*. By means of this organ, which they

elongate or contract at pleasure, the animals are enabled to burrow and to go "up and down stairs" with great rapidity. It requires dexterous management to capture the Razor-shell alive. When they are wanted for food or for bait, the usual plan is to shoot into the sand, alongside of a "spout," a hooked iron rod, which must be at once pulled out again obliquely, so as to fetch the shell.

A better way is to drop a little salt on its tail, or at least on its siphon-orifices. If this be done, the animal will rise partly out of its burrow—for it hates undiluted chloride of sodium—and may then be captured, if you be quick. But, if you should fail to seize the creature at the first attempt, in vain would you pour salt in the burrow; the mollusk now sees the artifice, and is not to be imposed upon a second time.

The *Aspergillum*, or Watering-pot Shell, derives its name from its perforated disk, which much resembles the snout of a watering-pot. This animal burrows into sand or bores into stone, wood, or thick shells.

Fig. 3.



Aspergillum, or Watering-pot.

When in its burrow, its narrow end, containing the openings of its siphon, protrudes. To the same group belongs the Flask-shell, which perforates shells of every kind, attaching them to itself by means of some natural cement. It thus often constructs around itself a casing like a flask, and hence its name.

We will close this notice of the Borers of the Sea with some account of the *Mya arenaria*, or Gaper-shell, which burrows into sand, and which derives its name, gaper, from the fact that its bivalve-shell gapes, to allow its long, stout tube to protrude. "It inhabits sandy and muddy shores," says Wood, "and, to an inexperienced eye, is quite invisible. The shell itself, together with the actual body of the mollusk, is hidden deeply in the mud, seldom less than three inches, and generally eleven or twelve inches from the surface. In this position it would be unable to respire were it not for the elongated tube, which projects through the mud into the water, and just permits the extremities of the siphons to show themselves, surrounded by the little radiating tentacles which betray them to the experienced shell-hunter."

ON THE CAUSES WHICH OPERATE TO CREATE SCIENTIFIC MEN.

By FRANCIS GALTON.

ON more than one occasion I have maintained that intellectual ability is transmitted by inheritance; and, in a memoir published last year in the "Proceedings of the Royal Society," I endeavored to explain what ought to be understood by that word "inheritance." Two points were especially urged; the first, that each personality originates in a small selection out of a large batch of wonderfully varied elements, which were all latent and competing; and, secondly, that these batches, and not the persons derived from them, form the principal successive stages in the line of direct descent. Hence follows the paradoxical conclusion that the child must not be looked upon as directly descended from his own parents. His true relation to them is both circuitous and complicated, but admits of being easily expressed by an illustration. Suppose an independant nation, A, to have been formed by colonists from two other similarly constituted nations, B and C; then the relation borne by the *representative government* of A to that of B and of C is approximately similar to what I suppose to be the relation of a child to each of his parents. But the existence of a slender strain of direct descent is shown by the fact of acquired habits being occasionally transmitted. We must therefore amend our simile by supposing the members of the governments of B and C to have the privilege of making emigration easy and profitable to their constituents, and also, perhaps, the governments themselves to have the power of nominating a few individuals to seats in the Legislative Council of A.

It appears to me of the highest importance, in discussing heredity, to bear the character of this devious and imperfect connection distinctly in mind. It shows what results we may and may not expect. For instance, if B and C contain a large variety of social elements, it would be impossible, without a very accurate knowledge of them and of the conditions of selection, to predict the characters of their future governments. Still less would it be possible to predict that of A. But if the social elements of B and C were alike, and in each case simple, such as might be found in pastoral tribes, then the character of their governments and that of A could be predicted with some certainty. The former supposition illustrates what must occur when the breed of the parents is mongrel; the latter, when it is pure. Now, no wild or domestic animal is so mongrel as man, especially as regards his mental faculties; therefore, we cannot expect to find an invariable resemblance between the faculties of children and those of

their parents. All that could be expected on the hypothesis of strict inheritance we do find; that is, occasional startling resemblances, and much more frequently partial ones. From this we have a right to argue that if the breed of men were more pure, the intellectual resemblance of child to parent would be as strict as in the forms of the equally pure breeds of our domestic animals.

I propose to refer in this article to a volume written by M. de Candolle,[1] son of the late famous botanist, and himself a botanist, and scientific man of high reputation, in which my name is frequently referred to and used as a foil to set off his own conclusions. The author maintains that minute intellectual peculiarities do not go by descent, and that I have overstated the influence of heredity, since social causes, which he analyzes in a most instructive manner, are much more important. This may or may not be the case; but I am anxious to point out that the author contradicts himself, and that expressions continually escape from his pen at variance with his general conclusions. Thus he allows (p. 195) that, in the production of men of the highest scientific rank, the influence of race is superior to all others ("prime les autres en importance"); that (p. 268) there is a yet greater difference between families of the same race than between the races themselves; and that (p. 326), since most, and probably all, mental qualities are connected with structure, and as the latter is certainly inherited, the former must be so as well. Consequently, I propose to consider M. de Candolle as having been my ally against his will, notwithstanding all he may have said to the contrary.

The most valuable part of his investigation is this: What are the social conditions most likely to produce scientific investigators, irrespective of natural ability, and *a fortiori*, irrespective of theories of heredity? This is, necessarily, a one-sided inquiry, just as an inquiry would be that treated of natural gifts alone. But, for all that, it admits of being complete in itself, because it is based on statistics which afford well-known means of disentangling the effect of one out of many groups of contemporaneous influences. The author, however, continually trespasses on hereditary questions, without, as it appears to me, any adequate basis of fact, since he has collected next to nothing about the relatives of the people upon whom all his statistics are founded. The book is also so unfortunately deficient in method, that the author's views on any point have to be sought for in passages variously scattered; but it is full of original and suggestive ideas, which deserve to have been somewhat more precisely thought out and much more compendiously stated.

Its scheme is, to analyze the conditions of social and political life under which the principal men of science were severally living at the

[1] "*Histoire des Sciences et des Savants depuis deux Siècles.*" Par Alphonse de Candolle (Membre Corr. de l'Acad. Sciences, Paris; Foreign Member, Royal Soc., etc.). Geneva, 1873.

four epochs 1750, 1789, 1829, and 1869. The list of names upon which he depends is that of the foreign members of the three great scientific societies of Europe—namely, the French Academy, the Royal Society, and the Academy of Berlin—in each case about fifty in number. There is a yet stricter selection on the part of the foreign associates of the French Academy, who number only eight at a time, and of whom there have been only ninety-two[1] in the last two hundred years. It is remarkable that we find in this very select list four cases of father and son—namely, a Bernoulli and two of his sons, the two Eulers, and the two Herschels.

From an examination of these lists the author draws a large variety of interesting deductions. He traces the nationalities and the geographical distribution of the distinguished men of science, and compares the social conditions under which they lived. He finds them to be confined to a triangular slice of Europe, of which middle Italy forms the blunt apex, and a line connecting Sweden and Scotland forms the base; and then he shows that, out of a list of eighteen different influences favorable to science, such as liberty of publication, tolerant church, and temperate climate, a large majority were found in the triangular space in question, and there alone. The different nations vary at the different epochs in their scientific productiveness;[2] and he elaborately shows how closely the variation depends on some

[1] List of the ninety-two foreign associates of the French Academy (three names of no scientific importance having been omitted, who were elected in early days—these are: Lord Pembroke, 1710; Duc d'Escalone, 1715; and Prince Lœwenstein-Wertheim, 1766). The names are arranged in the order of their election, and a dash (—) divides those elected before and after the year 1800:

Denmark: None.—Œrsted.

England: Newton, Sloane (Sir Hans), Halley, Folkes, Bradley, Hales, Macclesfield (Earl), Morton (Earl), Pringle, Hunter, Priestley, Banks, Black.—Maskelyne, Cavendish, Jenner, Watt, Davy, Wollaston, Young, Dalton, Brown (Robert), Faraday, Brewster, Herschel (Sir John), Owen, Murchison.

Germany (Ancient Confederation): Rœmer, Leibnitz, Tchirnhausen (de), Wolff, Margraff, Herschel (Sir William).—Pallas, Klaproth, Humboldt (de), Werner, Gauss, Olbers, Blumenbach, Buch (de), Bessel, Jacobi, Tiedemann, Mitscherlik, Lejeune-Dirichlet, Ehrenberg, Liebig, Wöhler, Kummer.

Holland: Huyghens, Hartsoeker, Ruysch, Boerhaave, Van Swieten, Camper.—None.

Italy: Guglielmini, Cassini (Dom), Viviani, Poli, Bianchini, Marsigli, Manfredi, Morgagni, Cervi, Poleni, La Grange (de).—Volta, Scarpa, Piazzi, Plana.

Poland: Jablonowski.—None.

Russia: Euler (the son).—None.

Sweden: Linnæus, Bergmann, Wargentin.—Berzelius.

Switzerland: Bernoulli (Jacques), Bernoulli (Jean), De Crousaz, Bernoulli (Daniel), Haller (de), Euler (Léonard), Tronchin, Bernoulli (Jean II.), Bonnet (Charles), Saussure (Hor. Ben. de).—Candolle (Aug. Pyr. de), Rive (de la).

United States: Franklin.—Rumford.

[2] The author's tables of the scientific productiveness per million, of different nations at different times, are affected by a serious statistical error. He should have reckoned per million of men above fifty, instead of the population generally In a rapidly-increas-

or other of the eighteen influences becoming favorable or unfavorable. The author, himself descended from the Huguenots, lays just stress on the influence of religious refugees, whose traditions were to work in a disinterested way for the public good, and at the same time to avoid politics. The refugees rarely had their property in land, of which the oversight occupies time, but in movable securities; thus they had leisure for work. Then, again, as they were debarred from local politics, the ambition, especially of those who had taken refuge in small countries, was to earn the approval of the enlightened men all over Europe, and this could most easily be effected by doing good work in science. Out of the ninety-two foreign associates of the French Academy, no less than ten were descended from religious refugees, usually in the third or fourth generation. Switzerland had eight out of the ten, and we may thence easily gather how enormously she is indebted to the infusion of immigrant blood. Similarly, the only two American associates—Franklin and Rumford—were descended from Puritans.

The blighting effect of dogmatism upon scientific investigation is shown both in Catholic and Protestant countries. The Catholics are the more dogmatic of the two, and they supply, in proportion to their population, less than one-quarter as many of the foremost scientific men as the Protestants. There is not a single English or Irish Catholic among the ninety-two French foreign associates. Austria contributes no name, and the rest of Catholic Germany is almost barren. In Switzerland, the scientific productiveness of the Catholics is only $\frac{1}{20}$ that of the Protestants. Again, the Catholic missionaries have done nothing for science, notwithstanding their splendid opportunities. In past days, when they were absolute masters of vast countries, as Paraguay and the Philippines, the smallest encouragement and instruction given at the college of the Propaganda to young and apt missionaries would have enriched Rome with collections of natural history. If any city more than others deserved to have the finest botanical garden and richest herbarium, it is Rome; but she has scarcely any thing to show.

The most notable instance of the repressive force of Protestant dogmatism is to be found in the history of the republic of Geneva. During nearly 200 years (1535 to 1725) its laity as well as clergy were absolutely subject to the principles of the early Reformers. Instruction was imposed on them; nearly every citizen was made to pass through the college, and many attended special courses at the Academy, yet, during the whole of that period, not a single Genevese distinguished himself in science. Then occurred the wane of the Calvinist authority, between 1720 and 1735. Social life and education be-

ing country like England, the proportion of the youthful population to those of an age sufficient to enable them to become distinguished is double what it is in France, where population is stationary; and injustice may be done by these tables to England in something like that proportion. They require entire reconstruction.

came penetrated with liberal ideas;[1] and, since 1730, the date of the first election of a Genevese to an important foreign scientific society—our own Royal Society—Geneva has never ceased to produce mathematicians, physicists, and naturalists, in a number wholly out of proportion to her small population.

The author argues from these and similar cases that it is not so much the character of the dogma taught that is blighting to science as the dogmatic habit in education. It is the evil custom of continually telling young people that it is improper to occupy their minds about such and such things, and to be curious, that makes them timid and indifferent. Curiosity about realities, not about fictions of the imagination, is the motive power of scientific discovery, and it must be backed up by a frank and fearless spirit. M. de Candolle, in spite of his anti-heredity declarations, enunciates an advanced pro-heredity opinion well worthy of note. He says it is known that birds originally tame, when found on a desolate island, soon acquire a fear of man, and transmit that fear as an instinctive habit to their descendants. Hence, we might expect a population, reared for many generations under a dogmatic creed, to become congenitally indisposed to look truth in the face, and to be timid in intellectual inquiry.

Can, then, religion and science march in harmony? It is true that their methods are very different; the religious man is attached by his heart to his religion, and cannot endure to hear its truth discussed, and he fears scientific discoveries which might, in some slight way, discredit what he holds more important than all the rest. The scientific man seeks truth regardless of consequences; he balances probabilities, and inclines temporarily to that opinion which has most probabilities in its favor, ready to abandon it the moment the balance shifts, and the evidence in favor of a new hypothesis may prevail. These, indeed, are radical differences, but the two characters have one powerful element in common. Neither the religious nor the scientific man will consent to sacrifice his opinions to material gain, to political ends, nor to pleasure. Both agree in the love of intellectual pursuits, and in the practice of a simple, regular, and laborious life, and both work in a disinterested way for the public good. A strong evidence of this fundamental agreement is found in the number of sons of clergymen who have distinguished themselves as scientific investigators; it is so large that we must deplore the void in the ranks of science caused by the celibacy of the Catholic clergy. If Protestant ministers, like them, had never married, Berzelius, Euler, Linnæus, and Wollaston, would never have been born. But to revert to what we were speaking about. There are some six different objects in the pur-

[1] In 1735, public opinion had become so tolerant that it was enacted that candidates for the ministry should no longer be required to make a declaration of faith, but simply to promise to teach and preach conformably to the Bible and to the light of their own consciences (p. 264).

suit of which most men spend their energies: three of them refer to self—namely, property, pleasure, and political advancement; the other three imply devotion to ideas—namely, religion, science, and art. Without a doubt, as M. de Candolle says, the former three occupy one half of the moral sphere of the human character, and the latter three the other.

It appears that the men distinguished in science have usually been born in small towns, and educated by imperfect teachers, who made the boys think for themselves. Nothing is brought out more clearly in the work than that the first desideratum in scientific education is to stimulate curiosity and the observation of real things, and that too much encouragement of the receptive faculty is a serious error. The author justly laments that the art of observation is not only untaught, but is actually discouraged by modern education. Children are apt and eager to observe, but, instead of encouraging and regulating their instincts, the school-masters keep them occupied solely on internal ideas, such as grammar, the vocabularies of different languages, arithmetic, history, and poetry. They learn about the living world which surrounds them out of books, and not through their own eyes. One of the reformations he proposes is, to make much more use of drawing as a means of careful observation, compelling the pupils to draw quickly the object they have to describe, from memory, after a short period allowed for its examination. He is a strong advocate for the encouragement of a class of scientific sinecurists like the non-working fellows of our colleges, who should have leisure to investigate, and not be pestered by the petty mechanical work of continual teaching and examining. Science has lost much by the suppression of the ecclesiastical sinecures at the time of the French Revolution, for there used to be many abbés on the lists of foreign scientific members, but they have now almost wholly disappeared. The modern ideas of democracy are adverse to places to which definite work is not attached, and from which definite results do not regularly flow. This principle is a wise one for the mass of mankind; but how utterly misplaced when applied to those who have the zeal for investigation, and who work best when left quite alone!

There is a curious chapter on the probability of English becoming the dominant language of the world in fifty or a hundred years, and being the one into which the more important scientific publications of all nations will, as a matter of course, be translated. It is not only that the English-speaking population will outnumber the German and the French, as these now outnumber the Dutch and the Swedish, but that the language has peculiar merits, through its relationship with both the Latin and the Teutonic tongues. It also seems that, in families where German and French are originally spoken, French always drives out the German on account of its superior brevity. When people are in a hurry, and want to say something quickly, it is more easi-

ly said in French than in German. Precisely in the same way English beats French. Our sentences don't even require to be finished in order to be understood, because the leading ideas come out first; but, as for old-fashioned tongues, their roundabout construction would be perfectly intolerable. Fancy languages, like Latin and Greek, in which people did not say "yes" or "no." M. de Candolle is very disrespectful to classical Latin. He says that one must have gone through the schools not to be impressed by its ridiculous construction. Translate an ode of Horace literally to an unlettered artisan, keeping each word in its place, and it will produce the effect upon him of a building in which the hall-door was up in the third story. It is no longer a possible language, even in poetry.

I have only space for one more of the many subjects touched upon in his book—that of acquired habits being transmitted hereditarily—and which has also formed the subject of a recent essay by Dr. Carpenter. That some acquired habits in dogs are transmitted appears certain, but the number is very small, and we have no idea of the cause of their limitation. With man they are fewer still; indeed, it is difficult to point out any one, to the acceptance of which some objection may not be offered. Both M. de Candolle and Dr. Carpenter have spoken of the idiocy and other forms of nervous disorder which, beyond all doubt, afflict the children of drunkards. Here, then, appears an instance based on thousands of observations at lunatic asylums and elsewhere, in which an acquired habit of drunkenness, which ruins the will and nerves of the parent, appears to be transmitted hereditarily to the child. For my own part, I hesitate in drawing this conclusion, because there is a simpler reason. The fluids in an habitual drunkard's body, and all the secretions, are tainted with alcohol; consequently the unborn child of such a woman must be an habitual drunkard also. The unfortunate infant takes its dram by diffusion, and is compulsorily intoxicated from its earliest existence. What wonder that its constitution is ruined, and that it is born with unstrung nerves, or idiotic or insane? And just the same influence might be expected to poison the reproductive elements of either sex. I am also informed, but have not yet such data as I could wish, that children of recent teetotallers who were formerly drunkards are born healthy. If this be really the case, it seems to settle the question, and to show that we must not rely upon the above-mentioned facts as evidence of a once-acquired habit being hereditarily transmitted.—*Fortnightly Review.*

THE SHERMAN ASTRONOMICAL EXPEDITION.

By EMMA M. CONVERSE.

SCIENTIFIC observers have long seen the importance of securing a position elevated above the fogs and impurities of the atmosphere at the sea-level, for the purpose of making more accurate astronomical and meteorological observations. Accordingly, Prof. Peirce, the Superintendent of the Coast Survey, petitioned Congress for means to carry out such an undertaking. Congress made an appropriation of $2,000 for this special object, independent of the geographical and topographical constants of the station.

Sherman, in Wyoming, situated on the highest point of the Union Pacific Railway, and on the Rocky Mountain range, was agreed upon as an eligible and convenient locality for the scene of operations; and the months of June, July, and August, 1872, were devoted to the work.

The party consisted of General R. D. Cutts, an experienced officer of the Coast Survey, who had charge of the expedition, Assistant Mosman, Aid Colonna, Prof. Young, Prof. Emerson, and Mr. Mead, of Dartmouth College. There were also a photographer, a mechanician, and two servants. The party had, as an escort, about a dozen soldiers from Fort Russell, at Cheyenne, who assisted in keeping the hourly series of meteorological observations, and were detailed to serve as a protection from possible attacks of hostile Indians.

It was not until July that the members from Dartmouth College were able to join the expedition. The trustees of the college had loaned their valuable telescope for the occasion. It has an aperture of $9\frac{4}{10}$ inches, and a focal length of 12 feet, with clock-work, and the usual accompaniments, and is fitted with an automatic spectroscope, having a dispersive power of 13 prisms. This telescope is one of the best in the country in optical perfection, and in convenience and handiness of mounting.

The summit of a slight elevation was chosen as an eligible locality for occupation. It was a short distance from the railroad-station, and about 40 or 50 feet above the track. Three shanties of rough boards were erected as observatories, one for the transit instrument, one for the meteorological apparatus, and one for the equatorial telescope. The altitude of the observatory is 8,300 feet above the level of the sea, the latitude a little more than 44°, and the longitude about 28° west from Washington.

It was thought that Sherman combined unusual facilities for accomplishing the desired object of the expedition, which was to test the advantages of a great elevation upon astronomic, and especially spectroscopic, work. The currents, impurities, and reflective power of the atmosphere at the sea-level, interfere greatly with studies of this kind,

while an elevation of 8,000 feet leaves more than a fourth of the atmosphere below it. The situation was one of remarkable natural beauty. On the east there was little to mark the altitude except the rocky soil and scanty vegetation; on the north there were picturesque piles of granite; on the north-west lay the Laramie Hills; from the north-west to the south towered the mountain-peaks, many of them covered with perpetual snow. Long's Peak and Gray's Peak were 60 miles away at the south; the great mass of Medicine Bow lay at the west, and between them, over the lower ridges, rose some of the high mountains of the Colorado parks.

The party being located, and all arrangements for observation being made as systematic as possible, work was carried on during the summer months in earnest, and attended with valuable results for the initiatory movement of a work of such magnitude. The weather proved to be unusually unfavorable. An old trapper, who had lived among the mountains for twenty years, said that the amount of cloudy and rainy weather was uncommon for the season. With the exception of a week, when every night and a greater part of ever day were fine, clear nights were rare, and clear days less so. There were but two afternoons when work upon the sun could be kept up from noon till sunset, though there were more than twenty cloudless mornings during the same time. The enormous snow-fall of the preceding winter accounted for the unusual weather-condition of the locality, and the snow, in the middle of July, was still lying to the depths of eight feet on the plateau at the base of the Medicine Bow Mount.

Notwithstanding these drawbacks, valuable scientific results were obtained in five different departments of observation, geographical, meteorological, telescopic, spectroscopic, and magnetic.

The geographical position of the station was completely determined, its longitude being obtained by telegraphic communication with Salt Lake City. It will, therefore, be for the future a reference-point and base for the numerous surveys which are being made in that part of the country.

A complete hourly meteorological record was obtained for nearly the whole of the months of June, July, and August, which, from the important position of the station, cannot fail to be of great interest and value.

The telescopic observations were full of promise for the result of future and more thorough work in that department. When the sky was unclouded the atmosphere possessed the most ethereal transparency. At night, myriads of stars invisible at lower elevations were plainly discernible. Nearly all the seventh-magnitude stars of the British Association Catalogue were clearly visible to the naked eye. Prof. Young, to whose report we are indebted for the facts recorded in this article, says that, in the quadrilateral forming the bowl of the "Dipper," he could see distinctly nine stars, with glimpses of one or

two more, while at Hanover he could only perceive the three brightest of them. The power of the telescope was correspondingly increased, so that an instrument of $9\frac{4}{10}$ inches of aperture was as effective as one with 12 inches at the sea-level. Some views of Saturn were exquisitely beautiful. The inner satellites, the details and markings of the rings, especially a dark stripe upon the outer ring, were clearly seen under powers ranging from 500 to 1,200. Besides the increase of the range of the instrument, the air was vastly more steady, and faint objects much more clearly defined.

The advantage was still greater in the careful spectroscopic observations that were made. Prof. Young had drawn up at Hanover a catalogue of 103 bright lines in the spectrum of the chromosphere; at Sherman the number was extended to 273, while, at moments of unusual solar disturbance, there were glimpses of at least as many more. Sulphur, strontium, and cerium, are almost certainly proved to be constituents of the solar atmosphere, and zinc, erbium, and didymium are strongly indicated. It was hoped that at the base of the chromosphere there might be seen the reversal of the dark lines of the spectrum, which is so wondrously beautiful at the commencement and close of a total solar eclipse. But in this hope the observers were disappointed; the appearance, at the distance of 1″ or 15″ from the edge of the photosphere, giving a spectrum principally continuous, most of the dark lines vanishing or being much weakened. This result confirms the observations of Secchi, who reports at the edge of the sun a layer giving a continuous spectrum.

Curious observations were made upon the spectra of sun-spots, and a catalogue was made of 155 lines more or less affected, either greatly widened or weakened, or reversed. A number of bright lines were found in the spectrum of the nucleus, and some peculiarly shaded, as if they were the product of a combination of elements which, from the reduced temperature over the spots, had been able to exercise their chemical affinities.

Many solar eruptions were watched moving with velocities varying from 150 to 250 miles per second, and pouring forth their whirlwinds and torrents of ejected gas through the molten atmosphere. The most interesting eruption was visible on the surface of the sun itself in the vicinity of a large spot.

The magnetic observations were as satisfactory as any that were made, and yet prove that, although our greatest magnetic storms are only remotely connected with solar influence, every solar paroxysm has a direct and immediate effect upon terrestrial magnetism. On the 3d and 5th of August there were violent paroxysms of solar eruption. At just the minute these eruptions took place, the record of the vertical Magnetic Force shows marked and sudden magnetic impulses, a peculiar shuddering of the magnetic needle for that very time. The photographic copies of the vertical Force Curve at Greenwich and

Stonyhurst show marked and characteristic disturbances at the corresponding points, which, allowing for the difference in longitude, were the very moments of time when the solar disturbances were watched at Sherman.

The work of the last summer accomplished by the Sherman Astronomical Expedition points clearly to the inference that a great national observatory should be established without loss of time, in that position on the American Continent most favorable to astronomical observation. Sherman is evidently not the place, on account of weather-conditions, but some mountain-station must be found adapted for the purpose, far above the fogs and impurities of the sea-level. A telescope, the best and largest that scientific resources can furnish, and a corps of observers devoted to the work, must be established on this permanent locality. Then, from this high point, sun, planets, stars, nebulæ, comets, and meteors, may be attacked by observers armed with the most effectual scientific weapons, until from the depths of infinite space come answers to some of the great problems that are puzzling the brains of thoughtful students of celestial mysteries.

A recent writer proposes that the whole civilized world shall contribute for a telescope which shall cost $1,000,000. Why should not America contribute enough from her vast resources to possess the most powerful one that can be built, and be the first among the nations to bring about great results, and make certainties of what seem now the shadowy possibilities of the future?

THE BATTLE OF LIFE AMONG PLANTS.

By MAXWELL T. MASTERS, M. D., F. R. S.

EVERY day, every hour, there is going on around us a veritable death-struggle. It excites little attention. People would be in no hurry to read the telegraphic dispatches concerning it from the seat of war, even if there were any to read. Special correspondents there are, but their letters are appreciated but by a few. Nevertheless, it cannot be said that mankind in general is not interested in the result of the struggle. On the contrary, little as the affair is heeded, it is of very serious import to the human race. Our food-supplies depend on it; the well-being of our flocks and herds is essentially dependent on it; the building of our houses, the fabrication of our raiment, are to a large extent contingent on it; nay, the soil beneath our feet, and the very sky above our heads, are materially, very materially, influenced by the result of the contest of which we are about to speak. Edward Forbes was wont to say that the movement of a periwinkle over a rock might be of greater consequence to the human race than the progress

of an Alexander; and the results of the wars of the plants are assuredly of no less importance, seeing that the very existence of an Alexander depends in no slight degree upon them. The campaigns we speak of are real; they are not mental figments, or allegorical illustrations. Success in the practice of horticulture, of agriculture, of forestry, depends on the action we men take toward the combatants. If we remain neutral, the weakest goes to the wall, overpowered by the stronger; if we interfere, we exert a very powerful influence for the time; but, immediately we cease to exert our power, the combat begins again, and with enhanced violence. The essence of successful cultivation often consists almost entirely in the removal of the plant from the influence of that hostile "environment" to which, under natural circumstances, it would be subjected. It is this that accounts, in a great measure, though of course not wholly, for the oft-observed fact that certain plants, flowers, and fruits, attain far greater perfection in our gardens than they ever do in their native countries.

That a war of extermination is thus going on around us may strike some with surprise. They are so accustomed to associate flowers and plants with peace and repose, that they are astonished to find that other far less amiable ideas may, with even more justice, be associated with them. And yet a moment's reflection, or a passing glance at the nearest hedge-row or pasture, will show the reality of the struggle. All that beautiful disorder, that apparently careless admixture of divers forms and colors—the sweeping curves of the brambles, the entwining coils of the honeysuckle, the creeping interlacement of the ground-ivy or the pennywort—all are but indications of the fray that is constantly going on. It would seem as if the weakest must succumb, must be overpowered by the stronger-growing plants, and so they are at certain places and at certain times; but, under other conditions, the victory may be with the apparently weaker side, just as the slow-going tortoise may outrun the fleeter hare. In any case, the success is often only temporary; the victor becomes in time the vanquished; the vanquished, in its turn, regains its former conquest; and so on.

It is proposed in the following notes to give a few illustrations of the nature and effects of this conflict, of the way in which it is carried on, and of the circumstances which favor it.

Agriculturists had long been practically conversant with the advantages derivable from the practice of not growing the same crop on the same soil for too long a period. The advantages consequent on this so-called rotation of crops are due to more than one cause; but it was Dureau de la Malle who, in 1825, called attention to the phenomenon of natural rotation. From long observation of what takes place in woods and pasture-lands, he established the fact that an alternation of growth, as he called it, occurs as a natural phenomenon. In pasture-lands, for instance, the grasses get the upper hand at one time, the

leguminous plants at another; so that, in the course of thirty years, the author whose observations we are citing was witness of five or six such alternations.

It follows from all this that a plant, as was pointed out by the late Dean Herbert, does not necessarily grow in the situation best adapted for it, but where it can best hold its own against its hostile neighbors, and best sustain itself against unfavorable conditions generally.

The sources of success in the contest are manifold; they vary more or less in each individual case. Probably they are never exactly the same; nevertheless, there are certain circumstances which must always be operative in conducing to the victory. A few illustrations must suffice. It is easy to understand why first-comers, duly installed, should have an advantage over later visitants; why the more prolific should outnumber the less fertile; and how it is that a perennial plant has a better chance on any given spot, *cæteris paribus*, than an annual, whose progeny would find the ground occupied, and their chances of survival materially interfered with by their longer-lived neighbors.

Again, there is no difficulty in understanding why such plants as quitch (*Triticum repens*) or bearbine (*Convolvulus sepium*) hold their own so tenaciously, and so much to the prejudice of their neighbors. The long, creeping, underground stems, rooting, or capable of rooting, at every joint, give them an immense advantage over plants not so favorably organized. The ends of the shoots of the convolvulus, moreover, dilate into tubers, which are thrust into the ground, to form in the succeeding spring fresh centres of vegetation. A great rooting-power is obviously of great benefit; not less so is an extensive leaf-surface. It is not only that the copious feeding-roots absorb the available nourishment from the soil, not only that the wide leaf-surface avails itself of every ray of sunlight, every whiff of air that plays over it, and thus serves to build up the tissues of the plant to which the root or leaf respectively belongs, but they practically oust other plants less favorably circumstanced than themselves. The roots occupy the soil, and rob the weaker plants of their share of its resources. The tree with dense foliage shuts off from its lowlier neighbor much of the light and air necessary for its existence; and hence, in a measure, the absence of vegetation in pine-forests or under the shadow of dense woods. Some plants there are specially organized to resist and overcome these hostile conditions. Among them are the climbers, the twining plants, and those with tendrils of one sort or another. The bramble or wild-rose, with its slender, arching, hook-beset branches; the wild-hop, with its coils of cord-like sprays; the clematis, clinging on firmly by means of its leaf-stalks to any thing it can lay hold of; the ivy, grappling with the trunk of a tree—all these are, in some sense, weakly plants; they would be overweighted in the struggle with their stronger neighbors, if it were not for the special adaptation of

their structure just alluded to, and which enables them to bear their part bravely in the conflict.

It is easy to understand how an alteration of the conditions under which plants grow influences very materially the struggle we have been alluding to. A very slight change in climatal conditions—produced, for instance, by the growth of sheltering trees, or by the drainage of the soil—may be followed by the growth of quite a different set of plants from those that occupied the ground previously. The altered conditions have been advantageous to the one and disadvantageous to the other set of plants.

As an illustration of the complexity of the checks and relations between organic beings struggling together, Darwin mentions the case of a barren heath which fell under his observation, part of which was left intact, while another portion had been enclosed and planted with Scotch fir. The change in the native vegetation of the planted part of the heath was most remarkable. "Not only the proportional numbers of the heath-plants were wholly changed, but twelve species of plants, not counting grasses and carices, flourished in the plantations, which could not be found on the heath."

This sort of change was pointedly referred to by Dureau de la Malle, who relates how, after the felling of the timber in forests of a particular district of France, broom, foxglove, heaths, birch-trees, and aspens sprang up, replacing the oaks, the beech, and the ash, felled by the woodman. After thirty years, the birch and poplars were felled in their turn. Still very few of the original possessors of the soil, the oaks, etc., made their appearance: the ground was still occupied with young birch and poplar. It is not till after the third repetition of the coppicing—after an interval of ninety years—that the oaks and beech reconquer their original position. They retain it for a time, and then the struggle begins again.

Antiquarian researches also have proved that, in the natural state of things, without any violent change in external conditions, the nature of forests becomes altered. The Hercynian forests, of which Cæsar speaks, and which then consisted of deciduous-leaved trees, are now made up principally of conifers. A forest which, in the middle ages, was of beech, is now stocked with oak, and *vice versa*. Again, we have the evidence afforded by submerged forests and peat-bogs, according to which certain plants, now extinct in particular localities, once flourished there. We are not alluding to plants that may have required a different climate from what they now experience, but to such cases as the silver fir, the Scotch fir, *Pinus Mughus*, etc., which are found in this partially-fossilized condition in spots where there is apparently nothing to prevent them from growing now, where, in fact, they do grow well when planted.

Foresters in all countries are perfectly well aware of these facts, and botanists watch with interest the appearance of a different vegeta-

tion, when some accident has interfered with the previously-existing conditions. When woods are cut down, when soil from a depth is laid on the surface, when extensive fires occur, when lakes are drained; in fact, when any sudden alteration takes place in external circumstances, then we may expect to find a corresponding change in the vegetation. One set of plants profits by the change, another suffers. It may be asked, "Where do the new arrivals come from?" Sometimes, no doubt, the seeds are wafted from a distance, and, finding a suitable abiding-place, germinate. This is, perhaps, more especially the case with the spores of fungi, whose extreme minuteness favors their dispersion in this way. But it often happens that the facts of the case will not admit of such an interpretation, and then we can only fall back on the supposition that the seeds or bulbs existed in the soil, but under circumstances not favorable to their development.

The ground in this way is looked on by Alphonse de Candolle and Darwin as a vast magazine of seeds, etc., capable of retaining their vitality for a more or loss prolonged period, according to circumstances, and ready to avail themselves of any change that may be beneficial to them. That this is so in some places has been proved by results, but it seems equally clear that this does not hold good in all places. Allusion has already been made to the apparently capricious appearance of our British orchids. The downs or the fields that in one summer yielded abundance of bee, of fly, or of spider orchids, may, in another year, scarcely furnish a single one. The explanation of this peculiarity lies in the special organization of the plant, well described by Prillieux and other botanists, from whose observations it appears that the plants in question naturally pass through several stages, which, for our present purpose, it is not necessary to detail, and these stages may be prolonged according to circumstances. The flowering stage is thus arrived at in one season, while in another all the energies of the plant may be taken up in forming tubers and leaves. A very remarkable instance of the fact just alluded to was communicated to the writer by a competent observer, Mr. George Oxenden, of Broom Park, Kent. This gentleman had been acquainted with a particular field for some forty years, during which time it had been under the plough, but at the expiration of this period it was laid down in grass, when the very next year a profusion of bee-orchids was observed in it. In this case the time was too short for seeds to have germinated and to have progressed to the flowering state. There seems no other solution than that the tubers must have been in the ground some time previously, but that, from the ploughing and cropping of the soil, they had not had a fair chance of developing flowers.

The facts we have mentioned are, in the main, intelligible enough. We can see the why and the wherefore without much difficulty; but it is not so always. For instance, it is difficult to account for the sig-

nal defeat that native plants often incur at the hands of invading strangers.

Why does the water-cress, harmless enough in our ditches, block up the water-courses in New Zealand to such an extent as to become a costly nuisance? What can there be in English ditches and canals so propitious to the growth of the American water-weed (*Anacharis*) as to have caused it to obstruct even our navigable rivers? In America, whence it came, it is no more of an inconvenience than any other water-weed. Why in other places does the white clover (*Trifolium repens*) overcome the native grasses, and dispossess them of their territory? Why has a particular grass, the *Stipa tortilus*, invaded the South-Russian steppes to such an extent as to displace almost every other plant?

There are numberless such instances—from that afforded by the island of St. Helena, in which the original vegetation is almost completely dispossessed, and its room occupied by foreign importations, to the banks of a Surrey river, yellow with the flowers of an American balsam—and the reason is not obvious. The fact is patent, and is not without analogies in the virulence with which epidemic diseases spread when introduced for the first time among a population not heretofore subjected to them.

Such cases as these recall the opinions of Humboldt and others on the antipathies of plants. According to this notion, certain plants are positively injurious to others, not so much by any peculiarity of structural organization as by the excretion of matters hurtful to other plants. It has been asserted, for instance, that the darnel (*Lolium temulentum*) is injurious to wheat; that a species of thistle (*Serratula arvensis*) is obnoxious to oats; that a spurge (*Euphorbia Peplus*) and a scabious (*Knautia arvensis*) are detrimental to flax; and spurrey (*Spergula arvensis*) similarly prejudicial to buckwheat.

In so far as this detrimental influence is due to any excrementitious product from the plant, the verdict given by modern physiologists amounts to "not proven." Some would even say "not guilty;" but we do not see clearly how those who take this view can reconcile it entirely with the existence of that natural alteration of which Dureau de la Malle speaks, and which is admitted by all subsequent observers.

Mere exhaustion of the soil will not account for the phenomena in all cases, because a crop will fail on a particular soil after a while, and yet chemical analysis of that soil will reveal the fact that the particular elements required by a given plant are still contained in sufficient abundance in it. Land, for instance, that is "clover-sick"—on which, that is, good crops of clover cannot be grown—is by no means necessarily deficient in the constituent required for the growth of the plant; and, indeed, in the Rothamsted experiments the constituents in question have been supplied as manure, but without any good result.

Again, root-excretions (assuming their existence) cannot be productive of injury, as we are assured by Dr. Gilbert that clover has been grown in the same plot of garden-soil at Rothamsted for eighteen years in succession, while only a few hundred yards off no condition of manuring has hitherto been successful in restoring the clover-yielding capabilities of the land.[1] Reverting, however, to the alleged antipathies of one plant to another, we may make passing mention of the curious circumstance recorded by M. Paul Levi,[2] that the lianas or climbing plants of the forests of Central America have their likes and dislikes, and that they will not attach themselves to particular trees even when brought into juxtaposition with them. It is significent that the trees which are thus slighted by the twiners are just such as are ill-adapted for the support of such plants, being such as have tall, unbranched trunks, with smooth bark and a dense, overhanging, dome-like canopy of foliage. It is not only the climbing plants that refuse to grow on such trees, but to a less extent, also, the mosses, ferns, orchids, Bromeliads, and other epiphytal plants.

It is obvious, from what has been previously said, that human interference affects these internecine conflicts of plants very materially. It is clear also that the cultivator can very often avail himself of them to his own profit. From this point of view the experiments and observations carried on at Rothamsted by Mr. Lawes and Dr. Gilbert are most important, especially those relating to the struggle among pasture-plants, and the circumstances favoring certain plants more than their fellows. No detailed report of these particular experiments has hitherto been published, and only a few scattered notices in the Proceedings of the Horticultural Society (June 2, 1868) have appeared concerning them. We can, however, give some idea of their scope and nature by stating that a part of the park at Rothamsted, which has been under grass for centuries, has been divided into plots of equal size, placed side by side under conditions as nearly equal as possible. Some of these plots have been left unmanured; others, some twenty in number, have, for the last ten or twelve years, been subjected to various manures, the constitution and proportions of which are accurately determined. The general herbage of the park, like that of the unmanured plots, consists of some fifty species of plants, including sundry grasses, clovers, docks, umbellifers and other plants commonly found in such situations. In the several manured plots a change is observable, sometimes slight, at other times vast, and the change does not show itself so much in the superior luxuriance of any one plant, or in the starved condition of another, as it does in the more or less complete exclusion of certain plants, and in their replacement by others. Thus, while the unmanured plots contain, say, fifty species of plants, others comprise less than half that num-

[1] *Journal of the Horticultural Society.* New Series, vol. iii., p. 91.

[2] Cited in the *Gardener's Chronicle*, 1870, p. 383.

ber; from some plots the clovers and umbellifers are banished altogether, while in other cases they may be proportionately increased. Even among the grasses the competition is very severe, and the result in some cases is that all or nearly all have to give way to the cock's-foot grass (*Dactylis cæspitosa*), the growth of which is so fostered by certain manures as to cause it to overcome its fellows and remain master of the situation. To the plots to which a mixed mineral manure, consisting of salts of potash, soda, magnesia, and lime, is applied, but little difference in the number of species is observable. On the other hand, manures containing ammonia salts, or nitrates, cause a great diminution in the number of species living in the plot to which they are applied. While the unmanured plots furnish by weight about 60 per cent. of grasses, the remainder, consisting of plants of other families, the plots to which admixture of mineral and nitrogenous manures is added, contain as much as 95 per cent. of grasses, and these belonging to a comparatively very few species. Salts of potash and lime, which are comparatively inert as regards grasses, manifest their influence in increasing the vigor and the absolute numerical proportion of the leguminous plants.

The manner in which these results have been arrived at is worthy of a short description in this place.

Notes are taken at frequent intervals during the season of growth, the appearance of the plants noted, their relative luxuriance observed, and their comparative tendency to produce flower or stem and leaf, the abundance of flowers, etc., etc. Root-growth is studied, and also the character of the soil in the various plots, and the way in which its texture and its capacity for holding or transmitting water are modified according to the manure applied. When the crop is cut from each plot, its weight is estimated, and also the amount of dry produce. In some cases chemical analysis is pushed further, and the ashes duly examined. In addition to these no trifling observations, three "separations" have been carried out at regular intervals. These separations consist in the picking out, from a sample of a certain weight taken from each plot, every fragment of every species contained in the sample. In this way the relative quantity and weight of each of the different plants in the several samples are accurately determined, and the proportion in the whole plot computed. The labor is enormous; but the results, when fully brought out, must be most important, both as regards the scientific aspect of the question, the history of the life-struggle between plants so circumstanced, and also as regards the practical hints to be derived by the cultivator.

Some experiments of a somewhat similar character, and bearing directly on the struggle for life among plants, have been made by Prof. Hoffmann, of Giessen, and they are of such interest that we introduce here a very condensed account of them, taken from the pages of the *Gardener's Chronicle*, 1870, p. 664.

In a previous set of experiments the Giessen professor had ascertained that the particular plants under observation grew equally well in all the varieties of soil in which they were placed, provided due care was taken to prevent the growth of intruding weeds. Having arrived at this result, Prof. Hoffmann next left the several plants to themselves, with a view of ascertaining how they would comport themselves, without assistance, against the inroads of weeds. The result was, that the weeds completely gained the upper hand, as might have been expected from their known habit. The species which held out longest was *Asperula cynanchica*. This plant, after having been grown in a bed for three years, and protected from weed-invasion by the use of the hoe, was then left to take care of itself. It held out for four years, but was ultimately elbowed out by the intruders. Acting on the principle of "set a rogue to catch a rogue," Prof. Hoffmann then set himself to observe the results of the internecine struggle between the weeds themselves, thinking that the ultimate survivors would perhaps prove to have special affinities for the soil in which they grew.

Thus left to themselves, the beds became so densely covered, that, in a square foot, the professor counted 460 living plants, and the remnants of many others, which had succumbed in the encounter. Every year, in July, the plots were examined, and every year the number of species was found to have diminished. Melilots, at first abundant, gradually disappeared; *Artemisia vulgaris* succumbed after two or three years; and so on, till at length only a few species were left, and these not only persisted, but slowly gained ground from year to year, and ultimately remained in possession of the plot. The plots under observation were 2 mètres 30 cents. long, 1 mètre broad, and all as nearly as possible under the same conditions, save that the soil was varied, in some cases consisting of the ordinary soil of the garden, in others of an admixture of lime, in others of sand, or of sand and lime, and so forth.

Of the 107 species under observation, all, or nearly all, found the most essential requisites of their existence equally well in all the varieties of soil; so that, other conditions being equal, the nature of the soil was indifferent. The species which remained victors, all the others being ultimately dispossessed, were *Triticum repens* (couch), *Poa pratensis*, *Potentilla reptans*, *Acer Pseudo Platanus* (sycamore), *Cornus sanguinea*, native plants; and *Aster salignus*, *A. parviflorus*, *Euphorbia virgata*, and *Prunus Padus*, derived from other portions of the garden.

It may, therefore, be inferred that the district in which these experiments were made would, in process of time, if no obstacle were afforded, become covered with meadows and woods—meadows in the low ground and woods in elevated places. Again, the experiments show that the survival of certain plants has not been influenced by the

nature of the soil; thus the couch-grass was ultimately spread over all the plots, whether of sand, or of loam, or of lime, whether drained or undrained. So also with *Poa pratensis* and *Potentilla reptans*. So that the chemical and physical nature of the soil, as has been so often shown in similar investigations, plays only a secondary part.

As to the action of shade, it was found by Prof. Hoffmann that low-growing plants, especially if annuals, disappeared rapidly, while taller-growing plants, such as couch, *Prunus Padus*, etc., survived. The survival of certain plants, then—couch, *Aster*, *Potentilla*, etc.—is due much less to external conditions than to the "habit" of the plant itself; that is to say, to the facility the plant has of adapting itself to varying external conditions, and thus of triumphing over others less favorably endowed in this wise.

The immediate source of victory lies in the powerful root-growth of the survivors, including under the general term "root" not only the root proper, but the offshoots and runners which are given off just below, or on the surface of the ground. Indeed, the latter habit of growth is more advantageous to plants in such a struggle than the development of the true root downward would be. Among those plants where the roots were equally developed there were, nevertheless, inequalities of growth, dependent, probably, on the greater need for light in some species than in others, etc.

It is clear from Prof. Hoffmann's experiments that, but for the continual use of the hoe, and the diligent extirpation of the weeds in our fields, the stronger-growing ones would not only destroy our crops, but also other weeds less vigorous than themselves. But they are not sufficient to explain all the conditions of this complicated problem; as is shown by the fact that, in the district adjoining the locality where Prof. Hoffmann's experiments were carried on, the predominant plants are not the same as those which ultimately proved victors in the experimental beds.

We may add that for two years a series of observations was carried on in the gardens of the Royal Horticultural Society, at Chiswick, with a view to ascertain how certain selected plants, twelve in number, and naturally growing in pastures, would be affected when growing by themselves, by the addition of manures of five different descriptions, and similar to those used at Rothamsted. In some cases the results of these experiments were unsatisfactory, from circumstances that need not be detailed here; still a large body of facts was accumulated, and, with reference to the property by which certain plants prove victorious in the struggle for life, it was clear that the natural habit or organization of the plant was, *cæteris paribus*, the mainspring of its success over its competitors. The several manures intensified or deteriorated this peculiar organization, as the case might be, and thus favored or impeded its growth accordingly.—*Popular Science Review.*

THE HIPPOPOTAMUS AND HER BABY.

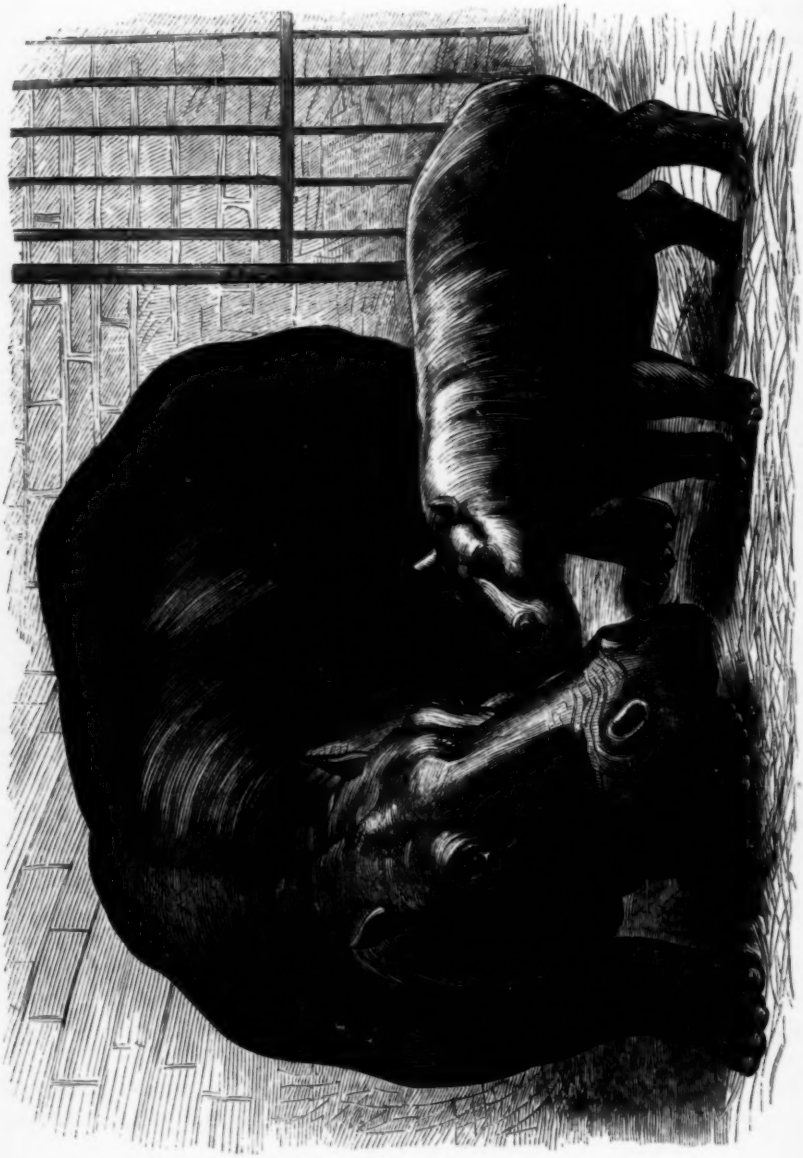
By FRANK BUCKLAND.

ON the 5th of November, 1604, two hundred and sixty-eight years ago, the whole of London was in a state of commotion at hearing of the discovery of "Guy Fawkes" sitting in a cellar under the Houses of Parliament, on a powder-barrel, with a match in his hand, his intention being to blow up James I. and the House of Lords.

On the 5th of November, 1872, London was again put in a state of commotion by the appearance of another "Guy Fawkes;" this time, however, not in the cellar under the Houses of Parliament, but in the straw by the side of his mother in her den at the Zoological Gardens. In the engraving on page 86, you can now, kind reader, see the portrait of this celebrated animal, "Guy Fawkes," so called on account of the date of his birth. The father hippopotamus came over here in the year 1851, and was accompanied in his journey by the well-known captain of the "Rob Roy Canoe," who happened to be a fellow-passenger in the steamer with him. The female hippopotamus was sent over to England, by my friend Consul Petherick, at a later date. From these parents three young ones have been born at the Zoological Gardens; unfortunately, two of these interesting infants died. I made two casts of the first Baby Hippo: one cast is in the giraffe-house at the Zoological Gardens, the other is in my Fish Museum at South Kensington. The first two young ones remained by the head of the mother, evidently not knowing where the udder was. Mr. Bartlett, the talented and ever-obliging superintendent of the Zoological Gardens, tells me that, before these two hippopotami were born, the people at Paris and Amsterdam had written to him to advise him "never, on any account, to let the baby hippopotamus go into the water." He took their advice on the former occasions, but at the birth of "Guy Fawkes" he was determined to try the very reverse plan. He therefore allowed the young one to accompany its mother into the big bath. It is to Mr. Bartlett that must be ascribed the honor of the discovery *that the young hippopotamus certainly sucks under water.* It would seem, therefore, that the young hippopotamus has some peculiar anatomical structure which enables it to remain a much longer time under water than its parents.

A few days after the birth of the young one, Mr. Bartlett was watching it swimming about the tank. It then suddenly dived, but did not reappear for such a long time that he thought it had had a fit, and was lying drowned at the bottom of the tank. He therefore made arrangements to have the large plug pulled out—this plug had been fixed expressly for this purpose—and to run off the tank quickly, so as to resuscitate the little beast if possible. They were just going

to do this, when Master "Guy Fawkes" suddenly reappeared, shaking his funny little horse-like ears, from the bottom of his tank, with a hippopotamic grin on his face, as much as to say, "Don't be frightened, I am all right; you don't know all about me yet!" The little beast had remained, without blowing or taking breath, actually under water for nearly twenty minutes. The parents have never been known to be under much over three minutes. I suspect Nature has given this



THE YOUNG HIPPOPOTAMUS AND ITS MOTHER.

wonderful power of remaining so long under water to the young hippopotamus, first of all, to enable it to suck—when the water has been clear, Mr. Bartlett has frequently seen it sucking under water—and, secondly, in order that it may be concealed from its enemies, though I am not at all certain but that a large crocodile would seize and swallow a young hippopotamus as a jack would swallow a roach.

Master Guy Fawkes, nevertheless, had one day a narrow escape of his life. In order to clean out the tank, one fine sunny morning the mother and child were let out into the pond outside. They both remained in the water as long as it suited them, and then the mother walked out with that peculiar stately gait which distinguishes this gigantic animal. The little one attempted to follow, but, unfortunately, he chose a landing-place at the corner nearest the giraffes' enclosure, just at the very point where there were no steps. The poor little fellow struggled and fought hard to get out, but could not, falling back exhausted into the water. His mother, seeing the distress of her child, immediately went back into the water, and, diving down, brought him up from the bottom. She then supported his head above water, in order to give him time to breathe. For nearly half an hour Mr. Bartlett and the keepers were in agonies. Of course, they dare not go to help Guy Fawkes, and there was no form of life-buoy they could throw to the struggling creature. At last the young one made a more vigorous effort than ever, when simultaneously the old one gave him a push with her tremendous head, and the little animal's life was thus saved. So we see that the hippopotamus is no fool; her instinct—mind, rather—told her how to save her young one.

It would be superfluous in me to attempt to describe this little animal, because every one ought to go and see it. It is about the size and shape of an ordinary bacon pig, but the color is something of a pinkish-slate. He knows his keeper very well: and when he has had his dinner is as playful as a kitten, popping and jumping about his den, and throwing up mouthfuls of hay, like a young calf. When first born he was small enough to come through the bars on to the straw outside his den, but soon he had grown so much that he could not get through. He used to put his head through the bars, and allow Prescott, the keeper, to rub his gums. The tusks of the lower-jaw were just beginning to cut the gum. His back teeth have not come yet; but they are obliged to be very careful about his diet, for he has already (when I write, in January) begun to pick a bit at the food prepared for him. I am pleased to be able to record that the council of the Zoological Society so fully appreciate Mr. Bartlett's cleverness in rearing this little beast, that they have voted him a silver medal and a purse, with a check in it. Prescott and the other keeper have also received a silver medal and a *douceur* from the society.

I now proceed to make some general remarks about hippopotami.

The hippopotamus is of some value commercially. The skin is

made by the natives into whips, which, I believe, are used to beat delinquents in Egypt; and I am told that they are exceedingly formidable weapons. To make the whip, the skin is cut into triangular slips, about five or six feet long, one end being pointed, the other broad; it is then coiled upon itself, and afterward dried in the sun, and, when finished, is light, dry, and elastic. The teeth of the hippopotamus are also of commercial value. Their structure is very peculiar. I have a tooth now before; it is hollow at one end, like the tusk of an elephant. When the animal was alive, this hollow was filled with soft pulp. The tooth is always growing forward as the pulp solidifies behind. The reader can easily see how this is, by examining the front tooth of the lower jaw of the next boiled rabbit he has for dinner. The outside of the tooth of the hippo is formed of a glass-like, hard enamel; it is exceedingly dense, hard, and flint-like. I have just taken down my old regimental sword, and find that, by striking it at the proper angle, a shower of sparks fly away from the tooth, like the sparks from a boy's "fire-devil" made in form of a pyramid with wet gunpowder. The teeth of the hippopotami, as in the rabbit, are sometimes liable to deformity. In the College of Surgeons there is the tooth of a hippopotamus which has grown nearly into the form of a circle. These teeth are, I believe, much sought after by dentists for making artificial teeth; and when a piece can be had of such a form as that the teeth can be worked in enamel, they preserve their color almost as in the natural teeth. The price of hippopotami-teeth is about thirty shillings a pound. Artificial teeth are also made from the tusks of the walrus, the sword of the narwhal, and also the teeth of the cachelot whale.

Not long ago, the old male hippopotamus at the Gardens suffered much from a decayed tooth. In former times he would have been shot, as was poor "Chunee," the elephant at Exeter 'Change. Mr. Bartlett, superintendent of the Zoological Gardens, with his ever-ready talent in meeting all emergencies, determined to pull out the tooth. He ordered the blacksmith to make a pair of "tooth-forceps," and a tremendous pair they were. The "bite" of the forceps just fitted the tooth of the hippo. By skilful management, Bartlett managed to seize Master Hippo's tooth as he put his head through the bars. The hippo, roaring frightfully, pulled one way, Bartlett and the keepers pulled the other, and at last out came the tooth, and Hippo soon got well again.

No animal in this world is made without a purpose, and we always find that the structure of an animal is admirably adapted to its mode of life. I believe that one of the principal duties which the elephant and rhinoceros unconsciously perform, is to cut paths through the dense forests and jungles in which they live. The home of the hippopotamus is among the aquatic forests at the bottoms of large rivers, such as the Upper Nile. It is probable that, in the days of Moses, these

animals abounded in Lower Egypt. I believe now they do not occur in any part of the Nile below the cataracts, the headquarters being the central and southern parts of Africa only; but I am afraid that, as civilization increases, so will the hippopotamus retreat. This huge animal spends most of its time in the water, and it comes out to feed at night. Above the cataracts of the Nile they are very destructive to the crops, as they eat an immense quantity, and trample down much more than they eat. The stomach contains as much as five or six bushels, and the large intestine is eight inches in diameter. They do not grind their food much, but rather munch it up. The reader should be curious to notice this at the Zoological Gardens. When the old hippo opens its mouth, a good-sized baby could as easily be put in as one puts a letter into a letter-box. As the elephant makes passes in the jungles, so it appears to me that one of the chief offices of the hippopotamus is to keep in check the dense vegetation in tropical climates, which, if allowed to accumulate, would block up the long reaches of rivers, and ultimately turn the flat lands into useless, fever-breeding swamps: so that we see this gigantic animal is of very considerable economic importance. This living machine for the destruction of fresh-water vegetation is admirably adapted for its work. Nature has not given him any hair, as that would be an incumbrance to it, and would not well conduce to its comfort when wallowing in the mud. The skin is, therefore, somewhat like that of a pig. If the animal had not some protection against the sudden changes of temperature induced by his going in and out of the water so frequently, he would always be either shivering or else unbearably hot. Nature, therefore, has given him a thick layer of fat between the skin and the muscles. The Dutchmen in Southern Africa call the hippopotamus the "Zee-coe," or "Sea-cow." My friend Mr. Mostyn Owen, who has travelled a great deal in Africa, tells me that they also call him the "Umzivooboo; and should the reader happen to visit the Dee, near Ruabon, he would be exceedingly likely to see a coracle floating down the river with a gentleman sitting in it fishing for salmon, and he would also probably observe the name "Umzivooboo" painted on the coracle in large letters.

In the water, the hippopotamus, though a gigantic beast, shows very little of his carcass. On referring to the engraving, it will be observed that the nostrils, eyes, and ears, are on the same level. The nostrils are each provided with a wonderful valve, by means of which he can open his nostrils to breathe, or shut them up to exclude the water. This beautiful mechanism is worked by what is called a "sphincter muscle." Reader, your own eyes are worked by a sphincter muscle. Stand opposite the looking-glass and wink at yourself, you will then see a sphincter muscle in operation. You do not require a sphincter muscle to your nose, because you are not amphibious. We find, however, that the seal, like the hippopotamus, can close his

nose at will with a sphincter muscle. Go and look at the seal in the Zoological. The valve which works the blow-hole of the whale and porpoise is of an analogous character. Strange to say, we find an animal that is not amphibious has his nostrils protected by this curious and beautiful valve. But you will probably never guess what animal this is. Well, it is the camel—the "ship of the desert." In the desert, where the camel lives, there are often "sand-storms," and the Creator has provided the poor camel with this wonderful structure to save him from suffocation when these terrible sand-storms occur.

Shortly after the little hippopotamus was born in the Zoological, a young rhinoceros was born on board a ship in the Victoria Docks, and this poor little animal, whose value was very great, unfortunately died—his mother lay on him and crushed him with her great carcass. Never mind, better luck next time.—*Leisure Hour.*

EUTHANASIA.

THERE is a small knot of thinkers in Birmingham who come together to discuss philosophical topics, and call themselves The Speculative Club. In 1870 they published a volume of seven essays, which were written with much ability, and some of them with great boldness. The sixth article of this volume is by Samuel D. Williams, and is entitled "Euthanasia," which being interpreted means an easy or desirable mode of death. The writer begins by referring to the opposition which was made to the administration of chloroform for relief of pain, and more especially in cases of childbirth, which was regarded as a revolt against the divine decree, "In sorrow shalt thou bring forth." This prejudice having passed away, the writer raises the question of the application of chloroform to a relief of the sufferings which often attend the approach of death, and observes: "It is difficult to understand why chloroform should be rightly recurred to, to render less painful the natural painful passage into life; and yet, that it should be almost an offence to so much as suggest a like recurrence to it in the still more painful passage out of life." Why, he asks, should the patient about to be operated upon by the surgeon always have a refuge from suffering open to him, and yet the patient about to suffer at the hands of Nature the worst she has to inflict, be left without help or hope of help? Mr. Williams lays down and defends the following proposition: "*That in all cases of hopeless and painful illness it should be the recognized duty of the medical attendant, whenever so desired by the patient, to administer chloroform, or such other anæsthetic as may by-and-by supersede chloroform, so as to destroy consciousness at once, and put the sufferer at once to a quick and painless*

death; all needful precautions being adopted to prevent any possible abuse of such duty; and means being taken to establish, beyond the possibility of doubt or question, that the remedy was applied at the express wish of the patient."

After describing the tortures of lingering disease leading to inevitable death, the writer remarks:

"Cases such as this abound on every hand; and those who have had to witness suffering of this kind, and to stand helplessly by, longing to minister to the beloved one, yet unable to bring any real respite or relief, may well be impatient with the easy-going spirit that sees in all this misery—so long as it does not fall upon itself—nothing but 'the appointed lot of man;' and that opposes, as almost impious or profane, every attempt to deal with it effectually.

"Why, it must be asked again, should all this unnecessary suffering be endured? The patient desires to die; his life can no longer be of use to others, and has become an intolerable burden to himself; the patient's friends submit to the inevitable, but seek the means of robbing death of its bitterest sting—protracted bodily pain; the medical attendant is at the bedside with all the resources of his knowledge and his skill ready to his hand; he could, were he permitted, bring to his patient immediate and permanent relief. Why is he not allowed to do so, or, rather, why should not his doing so be a recognized and sovereign duty?"

To the objection that such a course would be a violation of the sacredness of life, the author rejoins:

"It may well be doubted if life have any sacredness about it, apart from the use to be made of it by its possessor. Nature certainly knows nothing of any such sacredness, for there is nothing of which she is so prodigal; and a man's life, in her eyes, is of no more value than a bird's. And, hitherto, man has shown as little sense of the value of man's life as Nature herself, whenever his passions or lusts or interests have been thwarted by his brother man, or have seemed likely to be forwarded by his brother man's destruction. A sense of the value of his own individual life to himself, man has, indeed, seldom been deficient in; and, by a kind of reflex action, this sense has slowly given birth to, and alway underlies, the sense, such as it is, of the value of other men's lives. But even to-day, and amid the most civilized countries of Europe, 'the sacredness of man's life' is thrown to the winds, the moment national or political passion grows hot, or even when mere material interests are seriously threatened. And, indeed, seeing that life is so transitory a thing, and that, at the best, it has to be laid aside forever, within the brief space of its threescore years and ten, it is hard to understand the meaning of the word 'sacred' when applied to it, except in so far as the word may signify the duty laid on each man of using his life nobly while he has it.

"The objection, then, based on the sacredness of life, may be dis-

missed; life is a thing for use, and is to be used freely and sacrificed freely, whenever good is to be won or evil avoided by such sacrifice or use; the man who is ever ready to face death for others' sakes, to save others from grinding pain, has always been reckoned a hero; and what is heroic if done for another, is surely permissible, at least, if done for one's self; the man who could voluntarily give up his life to save another from months of slow torture, would win everybody's good word: why should he be debarred from taking a like step when the person to be rescued is himself?"

It is furthermore urged that the sacredness of life is violated by existing medical practice, where, in cases of extreme and hopeless suffering, physicians administer drugs which give present relief, at the expense of shortening the patient's life.

To the objection that submission to the will of Providence forbids the shortening of pain in this way, the writer replies that "by the same principle we should submit to the will of Providence, and not seek to escape any pain. Not submission to surrounding circumstances—another term for God's will—but successful effort to bend them to his purposes, is man's chief business here; and every useful thing he does is a successful attempt to change, for his own or others' benefit, some of the conditions of life which surround him."

And thus the author of "Euthanasia" goes on attacking current ideas, and taking his own view of the economy of the world. Nature is to him not a mighty, beneficent mother, any more than she is a dread and relentless power—

> "Red in tooth and claw
> With ravine."

"Death by disease is always death by torture, and the wit of man has never devised torture more cruel than are some of Nature's methods of putting her victims to death.

"One of the main facts, then, that men have to make familiar to their thoughts and to adjust their lives to, is, that they are born into a world on the painful riddle of which speculation can throw no light, but the facts of which press hard against them on every hand; and from these facts the truth stands out clear and harsh, that not enjoyment, but, in the main, struggle and suffering, is what they have to look for, and that, to bring this suffering into bearable proportions, should be one of the chief aims of their lives."

The publication of this essay made but little stir at first. But it was separated from the volume, and published in a pamphlet with preface by Rose Mary Crawshay, and in this shape went to the third edition. The subject has been lately taken up in the *Fortnightly Review*, by Mr. Tollemache, under the title of "A New Cure for Incurables." Planting himself on Mr. Williams's ground, he reproduces his chief arguments, and adds others, with a view of strengthening the case. To illustrate how far pain reconciles us to death, he says:

"It is probably from surgical cases that the strongest arguments for euthanasia may be drawn. One of the highest authorities respecting such cases, the late Sir Benjamin Brodie, said that a very moderate amount of pain, if continued for a long time, would make any one heartily tired of life. He remarked also, that during his whole life he had known only two dying persons who showed any fear of death; and that both those died of bleeding. One cause of this singular circumstance probably was, that in these two cases there was hardly any pain to distract the mind; and the fact is curious, as showing how rare, in Sir Benjamin's experience, such painless deaths must have been."

The publication of this paper gave the discussion a fresh impulse, and numerous articles and letters have appeared in the English press, a few in favor of Euthanasia, but most of them decidedly against it. The *Saturday Review*, which had at first coquetted with Mr. Williams's theory as a novelty, upon sober reflection condemned it. The following is a part of its argument:

"It is of primary importance to inculcate a regard for the sanctity of human life. The reluctance to take life is indeed often pushed to an extreme by the opponents of capital punishments. But nobody can say that the mass of the population have as yet pushed their tenderness to the verge of effeminacy. A little story, related for a different purpose in the *Fortnightly Review*, illustrates very prettily a sentiment which is not so uncommon as might be desired. A sensible Scotchman watching by the bedside of his dying wife became impatient at the poor woman's anxiety to express her last wishes, and civilly requested her to 'get on wi' her deeing.' Now, among the poorer classes, where the inconvenience inflicted by people who 'take an unconscionable time in dying' is necessarily felt much more keenly than with people in a different rank, it is to be feared that this delicate hint is frequently followed up by some practical remonstrances. 'They pinched his nose beneath the clothes,' as Barham says, on the authority of a real occurrence, 'and the poor dear soul went off like a lamb.' Suppose, in fact, the case of a small cottage, where the invalid has become a heavy burden upon his family instead of a support, where the expense of providing medicine and attendance is most seriously felt, and where the sick-room is also the only dwelling-room, must there not frequently be a strong temptation to give him a quiet push or two along the downward path? If it were understood to be the law that invalids might be finished off when the case was hopeless, would not the temptation be frequently overpowering? Yes, it is replied, but the doctor and the parson must be present. That is all very well, but, if the practice became common, the people would quickly learn to take the law into their own hands. For it is to be observed that this is one of the cases where nobody could tell tales. A man on the verge of death does not require to have his throat cut

or a dose of arsenic administered. A judicious shake, an omission to cover him properly, or the exhibition of an over-dose of laudanum, will do the business effectually, and no possible proof remains. Once allow that such things may be done with due precautions, and the precautions will soon be neglected as troublesome formalities. Why bother the doctor and the parson, why ask the sick man's consent, when the case is so clear? Of course the system need not be openly mentioned, but it would be speedily understood to be a highly convenient practice. The advocates of the scheme admit that the precautions of which we have spoken are absolutely necessary to prevent abuse; and we may add that it is simply impossible to enforce their observance. The practice itself once sanctioned, nothing is clearer than that people could, if they chose, carry it out in their own methods. No practice, again, could be more directly destructive of any strong persuasion of the sanctity of life. We need only read a few police reports, to understand how great is the existing tendency to violence of all kinds. Infanticide, as we know, prevails to a terrible extent, and wife-killing is not much less popular. Admit that the slaughter of invalids is also right under certain limitations, and it is easy to guess the consequences. The devotion which the poor display in cases of sickness is often among the most touching and amiable features of their character. In spite of the temptations we have noticed, they will often make noble sacrifices for the comfort of their dying relatives. Tell them plainly that they are rather fools for their pains than otherwise, and that they had better suggest suicide to the sufferer at the earliest opportunity, and you do your best to encourage, not merely suicide, but the cruel murder of a helpless man. A death-bed, instead of being the scene for calling forth the tenderest emotions and the noblest self-sacrifice, will be haunted by a horrid suspicion; the sick man fearing that his departure is earnestly desired, and his friends inclining to the opinion that killing is not murder, but kindness. The agitation of the question, what is the proper moment for smothering your dying father instead of soothing him, is not favorable to the development of those sentiments and the inculcation of those lessons which we generally associate with a sick-bed. In fact, the plan which certain eccentric philanthropists have advocated with such queer enthusiasm has a direct tendency to make men greater brutes than they are, and they are quite brutal enough already."

The *Spectator* objects that "the gravest of the merely rational objections we can bring against Mr. Tollemache is, that the ideas of which he is the advocate would plainly lead to two entirely new phases of feeling—impatience of hopeless suffering instead of tenderness toward it, where there was any legal difficulty in the way of getting rid of it by the proposed new law—and further, a disposition to regard people as 'selfish' who continued burdens upon others without any near and clear chance of the complete restoration of their own

powers. Suppose it were permitted, as Mr. Tollemache wishes, that, on receiving the testimony of two or three physicians that a man's case is hopeless, he might, if he chose, elect to die, and that popular feeling came to sanction that choice as the right choice; what can be clearer than that, in the absence of any relations to whom such patients were dear, and who took pleasure therefore in prolonging their life, there would spring up a tone of habitual displeasure and irritation toward all who chose to go on giving unnecessary trouble to the world, and that very soon the standard of 'unnecessary' trouble would begin inevitably to become lower and lower, so that all the organized charity which now expresses itself in our hospital system would gradually suffer 'a sea-change' into something by no means 'rich or strange'—a sort of moral pressure, on poor invalids with any thing like a prospect of long-continued helplessness, to demand the right of ridding the world of themselves? We say that it is in this reflex effect of the new code of feeling upon our thoughts of disease, in the transformation it would certainly make of pure pity into impatience and something like reproachful displeasure, that the extreme danger of arguing out this sort of question, on the superficial considerations of the balance of pain and pleasure for each individual case, is best seen."

In a letter to the same paper, Mr. F. A. Channing says: "It is odd that men whose thought is mainly an outcome of modern science should fail to apply what is, perhaps, the most striking conception of modern science—that of time in relation to growth—to questions such as this of Euthanasia. If the central human instincts on which morality rests are the slowly-won product of ages of moral growth, a practice out of harmony with the most fundamental of those instincts, however speculatively excellent, could not be introduced without mischief. It would sacrifice too much of human feeling before it had time to put itself on a rational footing. Even in the individual philosopher it may be doubted whether reason could remodel instinct so as to make the sense of duty in such a case really complete. In most men the overridden instincts would merely be replaced by selfishness and cruelty to the helpless. They would lose the gentleness of strength, without gaining the least glimpse of the new morality.

"In Euthanasia we are offered a refined copy of the customs of some savage tribes, among whom life is more difficult to maintain, and so less valuable. But, then, their instincts are on the level of their customs. There is no jar between calculation and sentiment, such as we should have. Such a jar would make the practice, if adopted among us, spring from an estimate of personal advantages, and not from the half-thought-out sense of what is best, which is duty to most men. And, where such imperative instincts as the desire to keep life for ourselves and our friends at all costs are directly repressed in forming and acting on this estimate, the result must be moral loss to all except the

philosopher who has had time to think his soul to oneness under the rule of reason. Euthanasia might become a wholesome doctrine if time should dissolve our present, perhaps animal, feelings, and replace them by more economical sentiments. But, as we are, it could only be an esoteric doctrine for the few who might have opportunities of ending hopeless misery by chloroform without giving needless pain to their friends. That is, it would be applicable only in the way Prof. Newman deprecates.

"It may, of course, be urged that there has been a latent change in men's notions of life and death which only needs expression, and that, if men talked freely, many would be found to talk Euthanasia. But facts like the growing aversion to capital punishment seem to point the other way. It is not because we feel less keenly the horror of murder, but because we are more scrupulous about taking even the least worthy life. Take the growing leniency toward infanticide. It is not because there is a change of opinion as to the duty of keeping even superfluous babies alive, but because we are more reluctant to take a woman's life in vengeance for a child's. Again, the sense that under certain circumstances it would be better for us or those dear to us to die, is surely far from being the true wish for death overwhelming the passionate impulse to keep up life to the last.

"It might be said, too, that the apology of Euthanasia stands on the same footing as the apology of cowardice, such as those French towns showed whose people did not think it worth while to hold out. Was it, or was it not worth while?"

FREEZING OF PLANTS AND ANIMALS.

By Prof. FR. MOHR.

TRANSLATED FROM THE GERMAN, BY J. FITZGERALD, A. M.

IT is a fact, as yet unaccounted for, that, whereas the thawing-point of ice is constant, the freezing-point of water may, under certain conditions, be brought considerably below the temperature at which ice begins to melt. In glass vessels, with free access of air, pure water may be reduced to a temperature of from 15° to 17° Fahr. below the thawing-point, or, in a vacuum, from 18° to 20° Fahr. without freezing. A slight concussion, or contact with any rough surface, but especially with ice or snow, causes congelation at once, and the temperature ascends to the thawing-point. This rise of temperature is usually explained by the transition from the liquid to the solid form; but this is, after all, no true explanation, but merely a putting together of two facts which are apparently very nearly related.

The greater fall of the freezing-point *in vacuo*, as compared with its fall in the atmosphere, would appear to be ascribable to the absence of small corpuscles (spores ?). The melting of ice, as also the freezing of water, is a purely chemical process, though commonly called physical. Here heat is converted into a chemical effect; and, conversely, a chemical effect into heat. The phrase, "heat becomes latent," can no longer satisfy us, for latent heat is no heat at all. Here centre some facts belonging to the organic kingdom, to which my attention has been called by a letter received from Herr Fr. Dönhoff, of Orsoy.

The humors of butterfly-pupæ, which pass the winter in the open air, remain fluid in the coldest climate. If we cut in two such pupæ, at a temperature of 15° to 13° Fahr., the two halves quickly congeal and become as hard as stone. Juices of plants which do not freeze during winter, remain fluid, as is shown by the flexibility of the cabbage-leaf; while wet frozen linen may be broken, but refuses to bend. If you crush the leaves of green or red cabbage at a temperature below the freezing-point, they freeze at once; and, if you cut in pieces the ribs of a cabbage-leaf, you cannot press water out of the ends, for it freezes the moment they are cut up. Here the question arises how it is that watery fluids remain liquid in the tissues of animals and plants, whereas they at once freeze when the tissues are injured. A constant supply of heat is not to be thought of in pupæ or in eggs, such as is found in animals. Here I will bring forward two facts which throw some degree of light upon this question.

If you throw upon a glass plate a thin layer of flower of sulphur, and melt it by the application of heat, you will find that the larger particles are the first to become dry and solid on cooling, and to assume the yellow color. The smaller particles, on the other hand, remain fluid at common temperatures. Under the microscope they are transparent, and may be spread out with the dry finger; a fact which proves them to be viscous. Hence it follows that minute particles of sulphur may be cooled 170° below their melting-point without solidifying, but not so with larger particles.

Once, in preparing phosphuretted hydrogen, I suffered the mixture of phosphorus and caustic alkali to cool in the retort. On taking the apparatus apart on the next day, the phosphorus was found to be still molten at a common temperature, though its melting temperature is 115° Fahr. On repeating the experiment, it was found that the phosphorus might be cooled to 38° Fahr. before it solidified. Thus it remained fluid 77° below its melting-point.

Another observation was made, as follows: One night, at ten o'clock, with the temperature at 4° Fahr., a dense fog lay over the Moselle, through which, however, the brighter stars were visible. A cold current of air was coming from the direction of a neighboring hill, some 350 feet in height. The mist advanced steadily from the hill over the valley, but was constantly renewed, as the cold blast

came in contact with the moist air over the stream. The following morning all the trees, especially the pines, were covered with a heavy hoar-frost, but on the land-side only, not on the water-side. On examining the ice-spicules, they were found to be perfectly crystalline, with angles of from 60° to 120°, and the long needles were made up of minute crystals set one upon another, and on one side resembling a flight of stairs. The particles of water floating in the air were, of course, of the temperature of the atmosphere, and consequently below the thawing-point. So soon as they came in contact with the points of the ice-spicules, they solidified, just as very cold water will when it is touched with ice. If the particles of mist had been changed into ice while still floating in air, they would have gathered upon the spicules of the pines in the shape of irregular pulverulent conglomerates, but would not have formed crystals. The plainly crystalline form of the ice-spicules shows, beyond a doubt, that the particles of mist were fluid at 4° Fahr. From these facts it follows that the minuter the particles of a liquid body are, the further they can be brought beneath their thawing-point without freezing.

If, now, we make an application of these facts to the above phenomena of organic Nature, we find that the reason why watery humors of pupæ, eggs, leaves and shoots, do not freeze, is because the cells containing these humors are very minute: in other words, the larger the cells the more quickly will plants freeze. It is well known that the young sprouts of vines, potatoes, and other plants, very readily freeze under a light frost, as was the case on May 12th of last year. Now, these young sprouts of vines are extremely juicy, containing a great quantity of water, and consequently but little cellulose. And, although the vines of the preceding year stood a winter temperature of 2° Fahr. without freezing, the sprouts of the self-same plants were frosted at 21° Fahr. Freezing expands the water and bursts the cells, and the break-up of the texture stops the process of growth. The buds of vines are more watery than the ligneous vines themselves. Hence, too, last winter, on the night of December 7th, many buds were frozen, while the vines were unhurt. On a vine eight feet in length, one of the latest of the buds rested on a wall covered with snow, and this shot forth in the spring, though all the other buds on the vine failed. It was the coming of the frost so early in December that made it so destructive, for the vines grow ever drier, and the sap tends toward the roots, from the beginning of autumn. This process had not gone so far in December as it would have gone in the first half of January, when usually the heavy frosts set in. Those branches whose buds are destroyed by frost, afterward die of their own accord, because the sap is unemployed, and the work of the leaf has ceased. Several of the vines remained green, and flourished toward the end of April on being pruned, but afterward dried up, as their buds were without life.

Hence we might draw the general conclusion, that all southern plants which are unable to endure our winter have large cells, and that, at the North, only such plants can be naturalized as answer to the requirement of small cells. As in Nature there are no *aims*, but only necessity, we may also hence conclude that a low temperature is favorable to the development of small cells. We have here, furthermore, an explanation of the hairy coats of animals. Animals which live in the North have all a thick coat, while those living in the south have a thin one. The mammoth was covered with hair 12 inches long, while his descendant, the elephant, who lives only in southern climates, is almost naked. Animals coming from the south, and acclimatized in the north, acquire hair, and *vice versa*. At the poles the fox wears his winter-coat the whole year through. In Sweden his coat remains for 10 months; in Germany, for 6 months; farther south, 3 months—until at last it is entirely dropped. No one will here discover an *aim*, but rather this necessary consequence, that a lower temperature produces a growth of hair in some way unknown to us. The same is true as to the development of cells. If, as a general rule, a warmer temperature necessitates larger cells, then the plants of southern regions will perish from the frost of northerly latitudes. The leaf of the potato-vine can never endure frost; but it is only in early spring that the plant can be visited by frost in temperate climates, and there is no frost in summer, while in autumn the tubers are protected by the soil. The young branches of the oak and beech (two trees belonging, indeed, to our climate) are quite as little able to endure the frost, and suffer from it severely during the night in spring. On the other hand, the spicules of the pine and the sword-shaped leaves of the yucca stand the severest cold of our winters.

As regards the temperature of those portions of plants (sprouts of vines, potatoes, etc.) which are killed by the spring frosts, we have no definite knowledge. It is probable that these parts become, by radiation, considerably colder than the shining bulb of the thermometer, and that they do not share in the temperature of the air, but fall to a lower temperature by radiation. In cloudy nights, when the thermometer shows 30° or 31° Fahr., nothing freezes, though the contrary takes place on bright nights. But here, too, the smallness of the cells appears to lower the freezing-point of water some few degrees.

Yet, in thus bringing into very probable relation two different facts, viz., the non-congelation of pupæ and leaves, and the fluidity of molten sulphur and of mist-particles, we have no complete explanation of the phenomenon. Such an explanation would show why it is that small particles have a different freezing-point from large ones of the same substance. This would require a very profound acquaintance with the nature of the molecular motion of heat, as also of chemical affinity.—*Gaea.*

PROFESSOR TYNDALL'S DEED OF TRUST.

I, JOHN TYNDALL, Professor of Natural Philosophy in the Royal Institution of Great Britain, having, at the solicitation of my friends, lectured in various cities of the United States, find the receipts and disbursements on account of these lectures to be as follows:

I. RECEIPTS.

From Boston, for six lectures	$1,500 00
" Philadelphia, for six lectures	3,000 00
" Baltimore, for three lectures	1,000 00
" Washington, for six lectures	2,000 00
" New York, for six lectures	8,500 00
" Brooklyn, for six lectures	6,100 00
" New Haven, for two lectures	1,000 00
Total receipts	$23,100 00

II. DISBURSEMENTS.

Before leaving England: wages of assistants during the preparation of the lectures; work of philosophical-instrument maker; new apparatus; sundry items for outfit; travelling expenses of myself and two assistants from London to New York—make a total of £671 6*s.* 8*d.* which, at the rate of $5.50 per pound, amounts to	3,692 31
In the United States: hotel and travelling expenses for myself and two assistants; other expenses incidental to lectures in Boston, Philadelphia,[1] Baltimore, Washington, New York, Brooklyn, and New Haven—covering a period of four months—*plus* travelling expenses of myself and my assistants from New York to London—make a total of	4,749 35
Present to Yale Scientific Club	250 00
Salaries to assistants for four months, £250, which, at $5.50 per pound, amounts to	1,375 00
Making the total disbursements	$10,066 66

III.

The total receipts are	$23,100 00
The total disbursements	10,066 66
Making the net proceeds of lectures	$13,033 34

As an evidence of my good-will toward the people of the United States, I desire to devote this sum of $13,033 to the advancement of theoretic science, and the promotion of original research, especially in the department of physics, in the United States.

To accomplish this object, I hereby appoint Prof. Joseph Henry,

[1] At Philadelphia I had no hotel expenses, but was most comfortably lodged at the house of my kinsman, General Hector Tyndale. He, I may add, paid his own hotel expenses wherever he accompanied me.

Secretary of the Smithsonian Institution, Washington City, D. C., Dr. E. L. Youmans of New York, and General Hector Tyndale, of Philadelphia, to act as a Board of Trustees to take charge of the above sum, to carefully invest it in permanent securities; and I further direct that the said Board shall, for the present, appropriate the interest of the fund in supporting, or in assisting to support, at such European universities as they may consider most desirable, two (2) American pupils who may evince decided talents in physics, and who may express a determination to devote their lives to this work. My desire would be that each pupil should spend four years at a German university, three of those years to be devoted to the acquisition of knowledge, and the fourth to original investigation.

If, however, in the progress of science in the United States, it should at any time appear to the said Board that the end herein proposed would be better subserved by granting aid to students, or for some special researches in this country, the Board is authorized to make appropriations from the income of the fund for such purposes.

I further direct that vacancies which may occur in said Board of Trustees, by death or otherwise, shall be filled by the President of the National Academy of Sciences.

If in the course of any year the whole amount of the interest which accrues from the fund be not expended in the manner before mentioned, the surplus may be added to the principal, or may be expended in addition to the annual interest of another year.

If at any time any organization shall be established, and money provided by other persons for the promotion of such original research as I have in view, I authorize the said Board of Trustees to exercise their discretion as to coöperating in such work from the income of this fund.

In witness whereof I have hereunto set my hand and seal this 7th of February, 1873, in the city of New York.

(Signed) JOHN TYNDALL (L. S.)

In presence of

(Signed) C. BURRITT WAITE,

(Signed) L. E. FULLER.

SKETCH OF SIR G. B. AIRY.

SIR GEORGE BIDDELL AIRY, the Astronomer Royal, was born on the 27th of June, 1801, at Alnwick, in Northumberland. His education was first cared for at two private academies, now at Hereford, now at Colchester. From the Colchester Grammar-School, when eighteen years of age, he went, in 1819, to Trinity College, Cambridge.

Three years afterward he was elected to a scholarship. In 1823, on his graduating B. A., young Airy came out as Senior Wrangler. In 1824 he obtained his Fellowship at Trinity. His degree of M. A. was taken in 1826, and he was simultaneously elected, though only then in his twenty-fifth year, as Lucasian Professor at Cambridge. Illustrious philosophers like Barrow and Newton had preceded him in the occupation of that historic chair. Latterly, however, the office had become, in a great measure, purely honorary, and might almost be said to have degenerated into a sinecure.

Prof. Airy, once elevated to that position, determined to avail himself of his professorship to the advantage alike of himself and the university. Consequent upon this determination, he for nearly ten years together—namely, from 1827 to 1836—delivered, with admirable effect, a series of public lectures on experimental philosophy, by which his scientific reputation was very considerably advanced. The series was all the more remarkable, inasmuch as it was one of the earliest means of effectively illustrating the marvellous phenomena constituting the now almost universally adopted undulatory theory of light. Two years after Prof. Airy's induction into the chair established by Lucas, the estimation in which he was held at the university was still further signalized by his election to the Plumian Professorship. Nominated to that post of authority and honor, he at once obtained, by right of his position, the supreme command of the Cambridge Observatory.

Already, even then, he began those remarkable improvements in the method of calculating and publishing the observations which eventually became the law at Greenwich and at all the other great observatories. As indicative of the energy and daring of his innovations at Cambridge, he superintended the construction and mounting, one after another, of a series of renowned astronomical instruments. In that observatory, he brought into use a noble specimen of the equatorial, being that peculiar description of telescope which has its fixed axis so directed to the pole of the heavens that the tube may be readily made to follow any star by a single motion. There, moreover, he brought into effective employment a mural circle of admirable construction, bearing a telescope which revolves in the plane of the meridian, the whole being rigidly bound into some immovable structure of ponderous masonry. Prof. Airy, in his thirty-fourth year, became Astronomer Royal. Thirty-eight years have since elapsed. Under his directions, it is hardly too much to say that the organization of the establishment at Greenwich has been completely transformed. He has given great regularity to its minute and multiform proceedings. He has contrived to establish newer and sounder methods of calculation and publication. He has introduced, constructed, mounted, and employed, a series of novel instruments for the advancement of astronomic research. Perhaps the finest transit-circle at present any-

where to be found is the one he there constructed in 1860, the circles being no less than six feet in diameter, and the telescope affixed between the two graduated disks being twelve feet long, and having an object-glass of as many as eight inches in aperture. Through this splendid apparatus the altitude of the stars, as well as the time of meridian passage, is now unerringly marked at the great national observatory. But the greatest of all the instruments established by him at Greenwich is a large, first-class equatorium, well known among astronomers.

During Sir George Airy's rule at the observatory he has, in the midst of his other labors, reduced the Greenwich observations of the moon and of the planets from 1750 down to the present time. Incidentally he has thrown considerable light on ancient chronology by his ingenious calculation of some of the most renowned of historical eclipses. Thrice the Astronomer Royal has taken occasion to visit the European Continent for the purpose of making more accurate observations upon the solar eclipse then eagerly anticipated. In 1854 he approximated more nearly than any previous investigation had done to the weight of the earth, through a series of experiments on the relative vibration of a pendulum at the top and bottom of Harton Coal-pit.

Sir George Airy has been repeatedly called into council on matters of grave difficulty by the government. He was chairman of the royal commission empowered to supervise the delicate process of contriving new standards of length and of weight, the old standards having been destroyed in 1834 in the conflagration of the Houses of Parliament. He was consulted some years afterward by the government in respect to the bewildering disturbance of the magnetic compass in iron-built ships-of-war. Thereupon he contrived an ingenious system of mechanical construction, through a combination of magnets and iron. The result was successful, and the system generally adopted. He conducted the astronomical observations necessary to the drawing of the boundary-line now traceable on the map of the New World between the Canadas and the United States. During the battle of the gauges in the railway world Sir George Airy strenuously advocated the narrow gauge, and he just as energetically advocates the adoption of a decimal currency. The writings of the Astronomer Royal are numerous. He has contributed largely to the Cambridge Transactions and the Philosophical Transactions. His pen has notably illustrated the memoirs of the Astronomical Society. He has written abundantly for the *Philosophical Magazine*, and still more abundantly, under his reversed initials, A. B. G., in the columns of the *Athenæum*. His principal works, however, are those which may be here rapidly enumerated: "Gravitation," published in 1837, was written originally for the "Penny Cyclopædia." "Mathematical Tracts" have reached a fourth edition, as have also his "Ipswich Lectures on Astronomy." In 1861 appeared his treatise on "Errors of Observation;" in 1869 his treatise on

"Sound;" and in 1870 his treatise on "Magnetism." Sir George Airy's well-known work on "Trigonometry" was published in 1855. Another work of his, entitled "Figure of the Earth," has yet to be named, as well as the luminous paper on "Tides and Waves," contributed by him, first of all, to the "Encyclopædia Metropolitana." Even while simply Professor of Astronomy at Cambridge his "Astronomical Observations," issuing from the press between 1829 and 1838, extended to nine quarto volumes, and were adopted at once as models for that class of publication.

Sir George Airy has received the Lalande Gold Medal of the French Institute in honor of his important discoveries in astronomy. For his successful optical theories he has had awarded to him the Copley Gold Medal of the Royal Society. The Royal Gold Medal of the same society has been given to him in recompense for his tidal investigations. Twice the Gold Medal of the Royal Astronomical Society has been his—first, for his discovery of an inequality of long period in the movements of Venus and the earth; secondly, in return for his reduction of the planetary observations. He has been enrolled among the most honored members of the Royal Astronomical Society, of the Cambridge Philosophical Society, and of the Institute of Civil Engineers. For many years past he has been among the foreign correspondents of the Institute of France, as well as of several other scientific academies on the Continent. He has received honorary degrees of D. C. L. and LL. D. from each of the three great universities—Oxford, Cambridge, and Edinburgh. On May 17, 1872, Sir George was gazetted a Knight of the Bath. His claim upon the remembrance of posterity, however, will be that of having occupied with distinguished ability the post of Astronomer Royal of Great Britain during considerably more than the lifetime of a whole generation.

The *Illustrated Review*, a London biographical and literary periodical, to which we are indebted for the preceding statements, remarks that, since the death of Sir John Herschel, on the 11th of May, 1871, Sir George Airy, the Astronomer Royal, is the admitted master of the sublime science. There are other eminent English astronomers —as John Hinde, the discoverer of many asteroids, and John Adams, also a Cambridge Senior Wrangler and the rival of Urban Leverrier, who groped his way by mathematical calculation to the discovery of the position of the hitherto unknown planet Neptune. If incidents as brilliant and remarkable as these are wanting in the history of Sir George Airy, his claims to respect are equally valuable, solid, and enduring.

CORRESPONDENCE.

THE SPHERE AND LIMITS OF SCIENCE.

To the Editor of the Popular Science Monthly:

AS you have done my brief after-dinner speech (a kind of performance that usually perishes with the occasion) the honor of an elaborate criticism, which I think a little one-sided and unfair, I ask the privilege to reply.

You say that I used the occasion of the Tyndall banquet "to give a lesson to the scientific gentlemen present as to the proper limit of their inquiries." But that is hardly a just representation. Neither in matter nor manner did I pretend "to instruct" anybody; but, assuming that the Press, on which I was invited to speak, was a kind of universal reporter, I simply asked a few questions of an audience so competent to give the answer, as to the validity of certain speculative opinions confidently put forth in the name of science. That the mode of doing so was neither presumptuous nor offensive, I infer from the cordial approval given to my remarks by eminent scientific gentlemen, both at the time and since.

You seem to resent the speech as an impertinence in saying that "it has ever been a favorite occupation of outsiders to instruct the investigators of Nature where they must stop," etc. But does Science set up any pretension to the character of an exclusive church? It is true I am an outsider; i. e., I have made no discoveries in science; I have cultivated no special branch of it as a pursuit; all that I know of it I have learned from others, by diligent though somewhat desultory reading, for thirty years past; but may I not, therefore, have an opinion of what I am taught? Is it temerity to endeavor to distinguish what is real science from what is not, particularly at a time when there is so much put forth that is likely to confuse the careless mind?

Be that as it may, what I complain of is, that you class me among the bigots, who in every age have protested against the progress of knowledge, alleging that I presented myself as "the champion of imperilled faith," whereas my protest was merely in behalf of true science against false. And, in order to make out your case, you suppress all reference to the first part of my speech, in which I uttered, as fully as the occasion allowed, the highest estimations of Science and my almost unbounded hopes of its future. Permit me to revive what I said: After hailing Science as the "King of the Epoch," to which all other forms of intellectual activity were doing homage, and as the "mighty Magician," that by its brilliant and fertile researches surpassed whatever the imagination had depicted in fable, I continued: "Science is to me not only a proof of man's intellectual superiority, and the seal of his emancipation from the tyranny of ignorance, but the pledge of an unimaginable progress in the future. By the beautiful uniformities of law, which it discovers in Nature, it discharges the human mind of those early superstitions which saw a despot god in every bush, whose wanton will paralyzed the free flight of our intellect, and debauched our best affections. Neither the tempests nor frowns of Nature are terrible to us, now that we may bend her most hostile forces into willing obedience, and find her full, not of malice, but of good-will. For, out of that benignity, and our supremacy over it, will yet come a power that will enable us to transform these poverty-smitten, sordid, unjust, and criminal civilizations, into happy and harmonious societies, when every man shall be glad in the gladness of his fellows, and, for the first time, feel the assurance of a universal Divine paternity. Science, moreover, in wresting from Creation her final secrets, will furnish to the philosophic mind the means of a more effulgent and glorious solution of the dark problems of life and destiny than it is possible to reach by unaided conjecture. She will prove what the spiritual insight of the seers has only dimly discerned, that Nature, which now seems so inscrutable to us, so hard and unfeeling toward human hopes

and desires, is the most kindly and generous of helpmates, and not a tyrannic lord; that these outward appearances are but the shows of an inward reality which is entirely human; that these phenomenal forms and events are but the symbols of an eternal Love and Truth, which the great spiritual Sun of the Universe projects and photographs upon the sensitive plates of our finite human intelligence."

Thus, while I ascribed to science a potent and beneficent efficacy, first, in discharging the mind of its fears of Nature and of other superstitions; second, in perfecting civilization; and, lastly, in promising the surest groundwork for speculative generalizations, both naturalistic and theological, you represent me as deprecating its influences, and as even questioning its utility. That was scarcely fair. How, indeed, could I do so? Holding profoundly to the conviction (how derived is not here the question) that there is but one real Life in the Universe, whose infinite Love is the ground of all Force, and whose infinite truth is the ground of all Law, and that phenomenal Nature is but the varied manifestation of that life to and through the human mind, it would be intellectual suicide in me to attempt imposing fetters upon any legitimate search of Nature's methods. Every step we make in unfolding her secrets is a new revelation of an adorable goodness and wisdom, and a new help toward a nobler future.

But then I said—and it was the whole purport of my speech, made in the interests of science as well as religion—that we can only expect these results from true science, which investigates what Nature really *is*, and not from a hasty and presumptuous science, which pretends to give us what Nature *may be supposed to be*. And my criterion of true science, suggested in a phrase, was, that the methods and results of it bear the impress of exactitude or certainty. You remark, as if you did not receive these simple and fundamental principles, that the "exact sciences" are exact, while others are not. There, I think, we differ or misunderstand each other. I am aware that none of the sciences are exact in the mathematical sense of the word, save the ideal or abstract sciences; but it is none the less true that the real or concrete sciences are exact, in the usual sense of the word, both in their methods and products. If they are not exact, where does the inexactness come in? In the observation of facts? Then the induction is vitiated. In the induction itself? Then the law arrived at is imperfect. In the deductive verification or proof? Then we have no reason for trusting our process. Biology, psychology, and sociology, you say, are sciences and certain sciences; to which my reply is, that, to the extent in which they are not precise, they are not sciences. Indeed, saving in a popular and convenient sense, I should be disposed to doubt whether they are yet to be ranked as more than inchoate sciences. They belong to the domain of science, have gathered some of the richest materials for science, and have attained to some extent a scientific value; but there is yet so much uncertainty hanging over broad regions in each that we must await the future for the resolution of many unresolved questions, which may give a new aspect to the whole. Biology is the most advanced, but rather in its natural history and classification, than in its knowledge of the profounder laws of life, that are yet to be found. Psychology is so little of a science, that the teachers of it hardly agree on the fundamental points; or, if it be a science, whose exposition of it are we to accept, Sir William Hamilton's or Mr. Mill's, Herbert Spencer's or Dr. Porter's, who all profess to be experimental and inductive, and all disagree? As to Sociology, the name for which was invented only a few years since by Comte, it is still in a chaotic condition; and, unless Mr. Spencer, whose few introductory chapters are alone made public, succeeds in giving it consistency and form, it can hardly be called more than a hope. But, be the truth what it may, in respect to these particular branches of knowledge, I still insist that certainty is the criterion of true science, and that, if we give that criterion up, science loses its authority, its prestige, its assurance of march, and its sovereign position as an arbiter in the varying struggles of doctrine.

Well, then the examples I gave, without mentioning names, of what I considered false science, were, first, the gross material-

ism of Büchner, who derives all the phenomena of life from simple combinations of matter and force; second, the atheism of Comte, whose scientific pretensions Mr. Huxley ridicules, and whose results Mr. Spencer impugns; third, the identification of mind and motion by Mr. Taine, which Tyndall, in one of his most eloquent passages, says explains nothing, and is, moreover, utterly "unthinkable;" and, fourthly, Mr. Spencer's evolutionism, which, in spite of the marvellous ingenuity and information with which it is wrought out, seems to me, after no little study, as it does to others more capable than I am of forming a judgment, after greater study, to be full of unsupported assumptions, logical inconsistencies, and explanations that explain nothing, while in its general character it tends to the sheerest naturalism. Now, was I right or wrong in regarding these systems as speculative merely, and not scientific? Am I to infer, from your objections to my remarks, that THE POPULAR SCIENCE MONTHLY holds materialism, atheism, and naturalism to be the legitimate outcome of science? Else why am I arraigned for designating them as unworthy of science, and as having no rightful claims to the name, under which their deplorable conclusions are commended to the public?

My object in these allusions was to indicate two capital distinctions, which it is always important to keep in view when estimating the scientific validity of a doctrine. The first is, that many questions determinable by science are not yet determined by it; and, until they are so determined, are to be regarded only as conjectural opinions, more or less pertinent or impertinent. Of this sort I hold the Nebular, the Darwinian, and the Spencerian views to be, i. e., hypotheses entirely within the domain of scientific theory, and capable, to a certain extent, of explaining the phenomena to which they refer; highly plausible and probable even at the first glance; but disputed by good authority, and not at all so verified as to be admissible into the rank of accredited science. They are suppositions to which the mind resorts to help it in the reduction of certain appearances of Nature to a general law; and, as such, they may be simple, ingenious, and even beautiful; but thus far they are no more than suppositions not proved, and therefore not entitled to the authority of scientific truth. You are probably too familiar with the history of scientific effort—which, like the history of many other kinds of intellectual effort, is a history of human error—not to know that, while hypothesis is an indispensable part of good method, it is also the part most liable to error. The records of astronomical, of geological, of physical, of chemical, and of biological research, are strewn with the *débris* of abandoned systems, all of which once had their vogue, but none of which now survive and many of which are hardly remembered. Recall for a moment the Ptolemaic cycles and epicycles; recall Kepler's nineteen different hypotheses, invented and discarded, before he found the true orbital motion of Mars; recall in geology Werner and Hutton, and the Plutonians and the Neptunians, superseded by the uniformitarians and the catastrophists, and now giving place to the evolutionists; recall in physics the many imponderable fluids, including Lamark's resonant fluid, that were held to be as real as the rocks only a few years ago; recall in chemistry, not to mention the alchemists and phlogistion, a dozen different modes of accounting for molecular action; recall in biology the animists and the vitalists, the devotees of plastic forces, of archei, of organizing ideas, and of central monads, all of them now deemed purely gratuitous assumptions that explained nothing, though put forth as science.

Even in regard to the question, so much discussed at present, of the gradual progression and harmony of being, the old monadology of Leibnitz, which endowed the ultimate units with varying doses of passion, consciousness, and spontaneity, and which built up the more complex structures and functions of organisms, from the combination of these—this theory, I say, somewhat modified and stripped of its mere metaphysical phases, could be made quite as rational and satisfactory as the more modern doctrines of development. Indeed, some eminent French *philosophs*—Renouvier, a first-class thinker, among the rest—have gone back to this notion; Darwin's suggestion of pangenesis, and Mr. Spencer's physiological units, look toward it; and

its adherents maintain that, beset with difficulties as it is, though not more so than others, it has yet this merit, that it leaves a way open to speculative thought, alike removed from the vagaries of mere ontological abstraction and the entire subjection of mind to a muddy and brute extraction. They might add, also, that this theory shows that, in the interpretation of the serial progress of being, we are not altogether shut up to a choice between specific and spasmodic creations and his own theory of evolution, as Mr. Spencer triumphantly assumes throughout his argument. Indeed, nothing is more easy than to make theories; but the difficulty is to get them adopted into Nature as the satisfactory reason of her processes. But, until they are so adopted, they are no more than the scaffolding of science—by no means the completed structure. Now, have the Darwinian and the Spencerian hypotheses been so adopted? Can we say that any questions on which such cautious observers and life-long students as Darwin, Owen, Huxley, Wallace, and Agassiz, still debate, are settled questions? Prof. Tyndall, for example, says: "Darwin draws heavily upon the scientific tolerance of the age;" and again, that "those who hold the doctrine of evolution are by no means ignorant of the uncertainty of their data, and they yield no more to it than a provisional assent." With what propriety, then, can a merely provisional conclusion be erected into an assured stand-point whence to assail traditionary beliefs as if they were old wives' fables?

More than that, a theory may be far more advanced than any of those; may be able to account satisfactorily for all the phenomena within its reach, as the Ptolemaic theory of the sidereal appearances did, even to the prediction of eclipses, or as the emanation theory of light did, up to the time of Dr. Young, and yet turn out altogether baseless. Nature is a prodigious quantity and a prodigious force; with all her outward uniformities she is often more cunning than the Sphinx; and, like Emerson's Brahma, she may declare to her students—

> "They know not well the subtle ways
> I keep, and pass and turn again."

We have looked into her face a little, measured some of her ellipses and angles, weighed her gases and dusts, and unveiled certain forces, far and near—all which are glorious things to have done, and some of them seemingly miraculous; but we are still only in her outer courts. Humboldt's "Cosmos," written thirty years ago, is said to be already an antiquated book; and Comte, who died but lately, and whom these eyes of mine have seen, could hardly pass a college examination in the sciences he was supposed to have classified forever. Let us not be too confident, then, that our little systems of natural law will not, like other systems of thought spoken of by Tennyson, "have their day."

The other distinction I had in mind, in my speech, was that, while there are some problems accessible to scientific methods, there are others that are not; and, that any proffered scientific solution of the latter, either negative or affirmative, is most likely an imposition. What I meant was that science, according to its own confession, that is, according to the teachings of its most accredited organs, pretends to no other function than to the ascertainment of the actual phenomena of Nature and their constant relations. The sphere of the finite and the relative, i. e., of existence, not of essence, and of existence in its mutual and manifested dependencies in time and space, not in its absolute grounds, circumscribes and exhausts its jurisdiction. Was I wrongly taught, Mr. Editor? Does science assert for itself higher and broader pretensions? Does it propose to penetrate the supernatural or metaphysical realms, if there be any such? Does it intend to apply its instruments to the measurement of the infinite, and its crucibles to the decomposition of the absolute?

You, as a man of excellent sense, will promptly answer, No! But, then, I ask, is thought, whose expatiations are so restless and irrepressible, to be forever shut up to the phenomenal and relative? Is it to be forever stifled under a bushel-measure, or tied by the legs with a surveyor's chain? May it not make excursions into the field of the Probable, and solace itself with moral assurances when physical certainties fail? May it not, mounting the winged horse of analogy, when the good old drudge-horse induction gives out, fly through tracts of

space and time, not yet laid down on the map? May not some men have insights into the working of laws yet unexplored, such as Mozart had into the laws of music, and Shakespeare into the laws of the human heart? Assuredly you cannot say nay, in the name of science, which, as we agree, being confined to the phenomenal and relative, has no right to pronounce either one way or the other, as to what, by supposition, lies beyond the phenomenal and relative. That supposed beyond may be wholly chimerical; but it is not from science that we shall learn the fact, if it be a fact. In other words, I contend—and here I hit upon the prime fallacy of many *soi-disant* scientists—that science has no right to erect *what it does contain into a negation of every thing which it does not contain.* Still less has it a right to decide questions out of its confessed province, because it cannot reach them by its peculiar methods, or subject them to its peculiar tests?

Fortunately for me, though you take me especially to task for it, I am sustained in this position by some of the most eminent men of science of the day, and I may say, by great numbers of them, as I have reason to know. You yourself published, only a little while since, Dr. Carpenter's address, as President, to the British Association for the Advancement of Science, in which, after expounding very clearly man's rightful function as "the interpreter of Nature," he said: "The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the order of Nature, it has separated itself wholly from theology, whose function it is to seek after its cause. . . . . But, when science, passing beyond its own limits, assumes to take the place of theology and sets up its own conception of the order of Nature as a sufficient account of its cause, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends."

In the same number you published Dr. Gray's address, as President of the American Association, wherein, after quoting Miss Cobbe's remark, that "it is a singular fact, that when we find out how any thing is done, our first conclusion is, that God did not do it," he adds, that such a conclusion is "premature, unworthy, and deplorable," and concludes with the hope "that, in the future, even more than in the past, faith in an order which is the basis of science will not (as it cannot be reasonably) be dissevered from faith in an ordainer which is the basis of religion." And, my old friend, and honored teacher, Dr. Henry, from whose enthusiasm for natural studies I imbibed whatever taste for them I have retained, in a letter addressed to this Tyndall banquet, and published in your last number, wrote: "While we have endeavored to show that abstract science is entitled to high appreciation and liberal support, we do not claim for it the power of solving questions belonging to other realms of thought. . . . Much harm has been done by the antagonism which has sometimes arisen between the expounders of science on the one hand, and those of theology on the other, and we would deprecate the tendency which exhibits itself in certain minds to foster feelings antagonistic to the researches into the phenomena of Nature, for fear they should disprove the interpretations of Holy Writ made long before the revelations of physical science, which might serve for a better exegesis of what has been revealed; and also the tendency in other minds to transcend the known, and to pronounce dogmatically as to the possibility of modes of existence on which physical research has not thrown, and we think never can throw, positive light." Now, here is precisely, though not all, my meaning, and yet you rap me over the knuckles for it, while you publish the praises of Carpenter, Gray, and Henry.

All these illustrious men admit the limits of Science, and also the possibility of passing beyond them. As men of good common-sense, and no less as philosophers and scientists, they are perfectly aware that, while the scope of Science lies within the contents of experience, and of the inductions drawn from that experience, it is hazarding the character of it to go further. They feel too, no doubt, what I certainly do, that there are certain broad, deep, ineradicable instincts of the human mind, which, however they originated, whether implanted there by creative act, or formed by the slow growth of thousands of years, are now become the inexpugnable basis of

all human credence and all human action. The convictions of the reality of Nature, of the independence of Mind, and of the being and authorship of God, in spite of every effort of Philosophy to get rid of them, either by declaring them unthinkable, or by merging one in the other, always return as the final no less than the initial postulates of thought. Any scheme of the universe, therefore, which leaves any of them out, declares itself impotent, like the project of an edifice which makes no provision for the corner-stones. Innumerable such schemes have gone before, and floated as bubbles for a while, but the first touch of these Realities broke them into thin air.

What the relations of these grand primal factors of the problem of existence are, or how they are to be harmonized with each other, we do not know; perhaps we never shall know; but, I think we shall learn more and more of them, and, in due time, by the instrumentalities that are given us. We shall learn of Nature, and of Man, so far as he is a dependant and denizen of Nature, by that digesting of experience which is the peculiar work of science. We shall learn of Man, so far as he has a deeper spring of life than observation reaches, from its wellings-up into consciousness at those rare moments of insight which often seem so mysterious; and we shall learn of God through both; i. e., as he works with the stupendous forces of time and space, which symbolize him, and as he inspires our feeble loves and wisdoms, which are no less symbols of him, with an intenser sense of his own supernal love and wisdom.

But, we shall learn little of either if we haughtily and peremptorily dismiss any of the elements out of the inquiry. Neither Nature nor Man is to be understood without God, nor can God be apprehended by pure intuition alone, or, save as he writes his hieroglyphics in objects and events, or imparts new impulses of goodness to the innermost soul. Tyndall, doubtless, caught a glimpse of the inseparableness of these elements when he said, "The passage from facts to principles is called induction, which, in its highest form, is inspiration,"[1] nor was he free from the same overshadowing truth, when, speaking of the possible solution of the ultimate physical problem, he remarks that, when it comes, "it will be one more of spiritual insight than of observation."[1] For, if deity be, as it is sometimes said, the Spiritual Sun, the intellectual Light, he may evade scrutiny, as the common light evades vision. It is the condition of vision, "the light of all our seeing," in which all objects are seen, though itself unseen. Besides, we know that, even in the common light, there are rays which the physical eyes do not see, which the inward eyes of reason alone behold, but which, if the physical eyes could be made sensitive to their swift pulsations, might disclose, according to Tyndall's exquisite suggestion, a new heaven and a new earth, immediately around us, and "as far surpassing ours as ours surpasses that of the wallowing reptiles which once held possession of this planet."

Science must not deny the finer rays which she cannot see; she may remain indifferent to them if she pleases, and is, indeed, largely obliged to remain indifferent because of the very conditions under which she works; but, while delving in matter, there is no reason for getting suffocated by its gases, or stifled in its mud. For, in that event, the narrowness and dogmatism you impute to "the classes still called educated," to "the cultivators of sentimental literature," and to "college-bred people," would be most unquestionably hers; the opposition to freedom and progress of thought that you deplore would be hers; and she would lose at once that devotion to truth, whithersoever it may lead, which is now her proud boast. Indeed, as I observe the world, pretension and bigotry are not confined to the circles where you discover them; there are so-called men of science who partake the fault; and who set up their own little area of outlook for the sum of God's measureless world. There are those who, because they may have attended a course of lectures on mechanics, or compiled a treatise on heat, or performed a few simple experiments in chemistry, assume, not that wisdom will die with them,

[1] "Fragments of Science," p. 60.

[1] Ibid., p. 100.

but that it was born with them. On the strength of these superior qualifications, they waive aside all the struggles of man after truth, in the past, as so many distempered dreams, which are about to be dispelled forever, because they have lit up a few farthing candles. Or, as a Buddhist poet says, "they are like infants born at midnight, who, because they see a sunrise, think there was never a yesterday." Let you and I, Mr. Editor, not be of the number. Let us be assured that some truth has come a good while ago, that it is coming still, in many ways, and will come in broader and rosier flashes in the future, though not to him who ostrich-like buries his head in the sand, or muffles his eyes against any of its illuminations.

I have the honor to be
Your obedient servant,
PARKE GODWIN.

MOMMSEN'S HISTORY AND THE STONE AGE IN ITALY.

MR. EDITOR: In Mommsen's "History of Rome"—one of the greatest intellectual productions of the age—vol. i., p. 30, American edition, occurs the following passage: "Nothing has hitherto been brought to light to warrant the supposition that mankind existed in Italy at a period anterior to the knowledge of agriculture and of the smelting of metals; and, if the human race ever within the bounds of Italy really occupied the level of that primitive stage of culture which we are accustomed to call the savage state, every trace of such a fact has disappeared."

Surprised at such a passage in such a book, I read it repeatedly, to be sure of its meaning. It seems to be plain enough. The statement is unwarranted; and, seeing that it is a negative one, it could hardly have been justifiable at the time it was written—probably twenty years ago. But, however that may be, it is certainly an oversight to retain it in the later editions without explanation.

Traces of early peoples who were savage in the extreme are plenty in many parts of Italy, even in the vicinity of Rome. Primitive stone weapons abound at Ponte Molle, Torre di Quinto, and Acqua Traversa, on the right bank of the Tiber. They are found in Liguria, and everywhere in what was Middle Etruria. Flint weapons of the rudest type are found in the lowermost beds of lava in ancient Latium. The like traces of a savage population are found at Imola, Casalvieri, and Alatri, in the neighborhood of Naples; at Ascoli, near Ancona; on Mount Brandon, in the vicinity of Ascoli, and on an island near Monticelli; in the territory of Borgo Ticino, on the plain of Vercelli-Borgo, and in the turf-pits of Mercurago and San Giovanni; in the region of San Germano, near Pinerolo, between the Tarnaro and Barrido, and on the right bank of the Agogna, in the territory of Briga; and in many other localities.

These relics consist mostly of hatchets and arrow or javelin points of flint and common greenstone. They are of all grades of workmanship, from the most rude to the most polished, and such is the variety in this respect that B. Gastaldi, who has thoroughly studied the specimens, believes that, if the usual division of the Stone Period into the Palæolithic and Neolithic (rough and polished stone) Ages be admissible, these relics would justify a further division of the Neolithic into two ages, according to the grade of workmanship.

Prof. Issel believes the evidence quite sufficient to show that the Ligurians remained stone-using savages, without knowledge of the metals, up to the time of their subjugation by the Celts and Romans.

It is trite to observe that unqualified statements resting wholly on negative support are unsafe. Still the learned continue to make them. This of Mommsen's reminds one of Rénan's archæologico-poetic assumption that the Egyptian civilization had no foreground of preparation. This appears very funny in the light of evolution. Whether the Egyptians were autochthones of the Nile or not, their civilization had a long period of beginnings just as certainly as the Hellenic had; and late discoveries, of what are believed by some of the highest authorities to be flint implements, indicate that Egypt was once inhabited by the rudest of savages. It is not safe to affirm of any spot on earth which has been long enough above water, that it has not been in-

habited by people in the stone-using phase of life.

J. S. PATTERSON.

BERLIN HEIGHTS, OHIO.

"A SPIDER'S ENGINEERING."

MR. EDITOR: The inquiry respecting the way in which spiders bridge chasms and streams, which is made in the note with the above heading, upon page 635 of the March number of this journal, has been often and satisfactorily answered by English writers,[1] and the following is given merely as a confirmation of their more extended observations:

In March, 1866, I had taken a living male and female *Nephila plumipes* (sometimes called the "silk-spider of South Carolina") to the photographic establishment of Mr. Whipple, of Boston; while waiting for the taking of their pictures, and standing about six feet from the wire frame upon which was extended the female's web, I saw the little male suddenly cease climbing about the frame, and take position upon its upper margin; in a few seconds a silken thread floated near me; I allowed it to adhere to my sleeve; the spider then turned about, and made several vigorous pulls upon the line, as if to ascertain its fixity of attachment; when satisfied of this, he rapidly made his way toward me, but, in order to observe the act again, I hung my end of the line over the frame, so that he was left where he started; after a few turns he took position as before, with his abdomen elevated and directed toward the spot I had occupied; presently a fine line shot out from his spinners, and pursued an undulating course until it reached beyond the spot I had occupied, and began to rise toward the large ventilating cupola in the centre of the room; the spider would occasionally turn and try the line as before, but it did not become attached, and he did not embark upon it.

Feeling now quite sure that the current of air toward the ventilator both determined the spider's preparatory action and the progress of the line, I removed this line, and blew gently upon the spider in the *opposite* direction; he immediately turned about, elevated the abdomen as before, *with the wind*, and soon a line was carried in this direction for as long and as far as my breath could reach, *and no farther*. This was repeated with the same result in various directions. The extremity of the line appeared blunt and a little enlarged, which is in accordance with the view of Blackwall respecting the way in which it is started:

"The extremities of the spinners are brought into contact, and viscid matter is emitted from the papillæ; they are then separated by a lateral motion, which extends the viscid matter into filaments connecting the papillæ; on these filaments the current of air impinges, drawing them out to a length which is regulated by the will of the animal, and, on the extremities of the spinners being brought together, the filaments coalesce, and form one compound line. . . . If placed upon rods set upright in glass vessels with perpendicular sides, and containing clear water, they in vain attempt to escape from them in a *still atmosphere*. . . .

"The lines produced by spiders are not propelled from the spinners by any physical power possessed by those animals, but are invariably drawn from them by the mechanical action of external forces."

It is not so very strange that an American journal should reproduce the note which suggested this communication, without incorporating the desired information, since very few papers upon spiders have appeared in this country; but the conductors of *Hardwicke's Science Gossip*, in which it first appeared, must have been strangely oblivious of the already-quoted English accounts of the subject.

But this oversight is pardonable when compared to what occurred in *Scribner's Monthly* for May, 1872, in an account of spiders, evidently a compilation. The common garden spider is represented *head upward* in the centre of a web composed of *concentric circles*. Now, every one that has really examined a so-called geometrical web knows that it consists of a *spiral line*, and *never of circles*; and also knows that the *Epeiridæ* are as averse to reposing head upward as human beings are to assuming the

[1] Blackwall, "Spiders of Great Britain and Ireland" (Introduction, p. 11); Journal of Proceedings of Linnæan Society, vol. vii.; Transactions of Linnæan Society, vol. xv., p. 455.

reverse position; they invariably hang in the web *head downward*.

Surely it is a little incongruous that a magazine which lectures THE POPULAR SCIENCE MONTHLY for occupying too much space with such "pseudo-science" as that "most high-flown speculation," Evolution, should expend money as well as space for an engraving which is not only controverted by every accurate observation, but which might have been corrected by a glance into Webster's Unabridged. BURT G. WILDER.

EDITOR'S TABLE.

SCIENTIFIC NORMAL SCHOOLS.

THE idea suggested by this title has long been with many a matter of vague and distant anticipation; but there is promise that something of the kind may soon become a realized fact. Rather, perhaps, we are to have a high-class Teachers' Institute on a strictly scientific basis. Professor Agassiz is expected to open, next summer, a school of natural history for the benefit of teachers during their vacation. He has associated with him twenty professors of high character to carry out the plan, and the object is, to afford ample facilities for studying specimens and becoming familiar with the actual properties and relations of living things. In an address before a committee of the Massachusetts Legislature on the claims of the Cambridge Museum of Comparative Zoology, Prof. Agassiz explained the nature and purpose of the contemplated project, which is kindred to the object for which the museum itself was founded. Education must have its storehouses of implements. For philosophy, history, and literature, public libraries are established, because these subjects are to be studied by means of books. But, in science, books are not sufficient; specimens are indispensable. We want, said Prof. Agassiz, to educate men who shall be able to read Nature, and this can only be done by studious familiarity with natural objects. The school is to carry out this plan. Nantucket Island has been selected as the location, and provision is made for a very thorough and comprehensive course of instruction.

This idea is certainly capable of extension, and the time, we think, has come when it should be taken up and carried out in different parts of the country. The Nantucket scheme could not be copied in the interior, because one-half of its subjects pertain to the natural history of the sea. The scheme is constructed from Prof. Agassiz's point of view, and is devoted mainly to zoology. The botany of land-plants is not included; entomology gets but little attention, and physics none at all. This is not intimated as a deficiency of the programme, which is sufficiently broad, and lays out more work than there will be time to do it in. It is evidently designed for the advantage of professors and teachers of science in educational institutions who already know something of the subjects, and desire the opportunity of perfecting their knowledge of natural history under the ablest instructors.

But the time has come for entering upon similar arrangements in behalf of the multitude of teachers in our common schools. We have normal schools for their preparation, but they are fashioned upon the old academic and collegiate pattern, and furnish only a book-education. The little science they pretend to give is book-science, and not the knowledge of things. Throughout nearly all of the common schools of the country, physics, chemistry, botany, and zoology, are taught, if taught at all, by the same method as

history or Latin—that is, by committing and reciting lessons from books. It is universally admitted that this is absurd, but what to do about it is the difficulty. The system is self-perpetuating. The normal schools go on in the old ruts, and continue to furnish teachers of the old type. Higher standards of attainment may be exacted in the routine branches, and there is unquestionably some improvement in methods; but little is done to bring the minds of pupils into familiar relations with Nature. Scarcely any thing is done for the thorough cultivation of the observing powers by exercising them upon objects and experiments. In response to the demand for studying Nature, we have only the rude expedient of object-lessons for children, administered by teachers who know nothing of physical science on the one hand, nor the science of the growing mind on the other.

What we want in every State in the Union is what Prof. Agassiz is preparing to supply in Massachusetts, an opportunity for teachers to come together, where there are cabinets, laboratories, specimens, and experiments, and an able corps of instructors who are at home with all these resources, and can teach directly from Nature herself. If the vacation-weeks only are to be devoted to this work, the scheme of studies will require to be drawn up with strict reference to their urgent and practical requirements. Nantucket will be favorable for studying the zoological productions of the sea; but Nature is an inexhaustible museum, and every place abounds with the material for the illustration of scientific study. The air, the fields, the woods, and the streams, swarm with life; the rocks are uncovered, minerals abound; the earth is carpeted with vegetation, the forces of Nature are ever playing around us, while every family, school, church, factory, poor-house, jail, neighborhood, and village, affords materials for the scientific study of social phenomena and laws. What is needed is, to teach teachers to bring their minds to bear directly upon those things, to observe, compare, and analyze them, so that their knowledge may be real, positive, and worthy the name of science. It may not be easy to found a proper curriculum for a scientific teachers' institute, selecting just the proper subjects, and assigning them their due proportions; yet the work is entirely practicable, and experience would soon fix the adjustments. As a preliminary step to such a movement, nothing could be better than a national convention of teachers, professors, and school superintendents, called for the distinctive purpose of laying down the plan and organizing the means for the promotion of scientific education. Prof. Agassiz has broken the ice, and will show us what it is possible to do in this direction during a single vacation. His enterprise is a national movement, and at once raises the important question as to how similar advantages may be gained for the general education of the country.

Since the above article was put into type, an important change has taken place in Prof. Agassiz's programme. He has been presented with an island as a location for his school, and with a $50,000 endowment to assist in defraying its expenses. The donor is Mr. John Anderson, of New York, and the island of 100 acres, known as Penikese, is one of the Elizabeth group, near New Bedford, four miles from the main-land, and twenty-four miles from Newport. It has been the summer residence of Mr. Anderson, and contains such buildings and improvements as a wealthy occupant would construct for purposes of residence. What the effect of this change will be upon the original plan is yet problematical, but it can hardly fail to be considerable. We see it stated that $30,000 addi-

tional is required to erect suitable buildings, and $200,000 more to raise the endowment to the point necessary for carrying out Prof. Agassiz's plans. If these arrangements be consummated, a Natural History school of high character and large usefulness cannot fail to be the result. How far it will be organized in the interest of original scientific investigations, or in the general interests of education, or to what degree both objects will be combined, remains to be seen. It is to be hoped that Mr. Anderson's generosity will prove contagious, and that not only will Prof. Agassiz be furnished with the funds he requires, but that men of wealth in different parts of the country will contribute to kindred enterprises in their own localities. For the organization of such Scientific Teachers' Institutes as we have suggested, large sums of money would not be required. Buildings can be found suitable for school sessions, lectures, and demonstrations, and no care or outlay would be necessary to provide for the living of students and professors. The expenses to be incurred would be only for the liberal remuneration of the professorial corps, and for the various scientific appliances needed to illustrate the teaching. The project is feasible, if there is sufficient interest in the subject to carry it out.

MR. GODWIN'S LETTER.

We publish an able communication from Mr. Parke Godwin, called forth by our strictures, in the April Monthly, on his speech at the Tyndall Banquet, and restating, with more fulness, the views there expressed. With much that he says we cordially agree, and, had the position to which we mainly objected been originally stated as it is now, there would have been less occasion for criticism. In his address, after some remarks on the great results of modern science, Mr. Godwin said: "But it is real science, with its rigid restrictions to its own sphere and its exact methods, and not any pseudo-science, that will accomplish these grand results." He then gave examples, and classed among them the doctrine of Evolution as interpreted by Herbert Spencer. But, in his present communication, Mr. Godwin admits that "the nebular, the Darwinian, and the Spencerian views are hypotheses quite within the domain of scientific theory, and capable, to a certain extent, of explaining the phenomena to which they refer." He allows their legitimacy, which is what we contended for; but he denies that they are fairly-accredited scientific truths, and here we suspect he is again mistaken.

What, then, are we to understand by scientific truth? Mr. Godwin inventories the chimeras of the past, and, pointing to the *débris* of abandoned theories which strew the road of science, admonishes us not "to be too confident that our little systems of natral law will not, like other systems of thought referred to by Tennyson, have their day." The lesson is a wholesome one; but are scientists the parties that most need it? Is it they that are forever affirming "finalities," "absolute verities," and "eternal principles?" In what school are men so trained to distrust themselves, and to hold their views subject to constant revision, as in the school of science? Is it not ever seeking to supersede existing truth by larger truth? Chemistry reposes upon its ascertained elements, but chemists are prepared to see them at any time abolished or resolved into a single one, and in that case the gentlemen of the laboratory would be the first to throw up their hats in exultation. Even the principle of gravity is not held as a finality: Faraday labored for its reinterpretation, and, should it disappear in some larger generalization of dynamical law, physicists will not go in-

to mourning. In science, the passing away of systems is generally an absorption of lesser into more comprehensive laws. The question of the truth of a new scientific theory is not as to its everlastingness, but as to its superiority to the views it seeks to supersede. Does it involve fewer assumptions? Does it account for more facts? Does it harmonize conflicting opinion? Does it open new inquiries and incite to fresh research? These are the tests that determine the acceptance of the theory, and, if it fulfils these conditions, it is held to be true.

Now, how does the doctrine of Evolution answer to these tests? It has arisen as an outgrowth of the latest and highest knowledge, has steadily made its way, in the teeth of inexorable criticism, to a large acceptance among the most disciplined thinkers of the period. It has been simmering in the minds of men of science for a century, and has now reached a point where it is capable of being formulated; where it is of great and acknowledged value for the guidance of scientific exploration, and it thus answers to the highest uses of theory. It is, moreover, becoming every day increasingly consonant with facts in the various branches of science, and is now far more congruous with the state of knowledge than any other hypothesis yet applied to the range of facts which it attempts to explain. The proof of the theory is unquestionably incomplete, but all theories are accepted under the same conditions. At the worst, it stands to-day where the theory of gravitation stood in the time of Newton, which, as Baden Powell remarks, "was beset by palpable contradictions in its results till many years after Newton's death."

On a complex and difficult scientific question of this kind, authority goes for something, and Mr. Godwin recognizes it. He remarks: "Can we say that any questions, on which such cautious observers and life-long students as Darwin, Owen, Huxley, Wallace, and Agassiz, still debate, are settled questions?" Certainly not; but, when their fundamental principles are accepted by four out of five of the eminent authorities which are cited as differing about them, we must acknowledge that the weight of authority is very strongly on one side. Nor is this all. The eminent scientific men who have adopted the view of Evolution, and that, too, against the powerful pressure of public prejudice, are to be numbered by scores and hundreds. In fact, the movement among naturalists, for the last ten years, toward a general doctrine of development, has amounted almost to a "stampede." This is not mere unsupported assertion. Here comes the latest scientific book of the season, "The Depths of the Sea," by the eminent Professor of Natural History in the University of Edinburgh, Wyville Thompson, and he says: "I do not think that I am speaking too strongly when I say that there is now scarcely a single competent general naturalist who is not prepared to accept some form of the doctrine of Evolution." Prof. Agassiz, indeed, still clings to his long-cherished opinions; but it is notorious that, on this question, his old students are running away from him, and his hypothesis, that there is an epidemic aberration upon this subject among the naturalists of the age, will hardly be held as a sufficient explanation of the phenomena. On the basis, therefore, of the judgment of the great body of those most competent to form an opinion, we cannot help thinking that Mr. Godwin was not only in error when he characterized the theory of Evolution as counterfeit science; but that he is also in error when he declares it to be a fugitive speculation, and not an accredited principle, entitled to the weight of valid scientific authority.

But, aside from the question of authority, Mr. Godwin argues against the

validity of biological and psychological sciences on the intrinsic ground that they lack exactitude. It would have been a point gained for his argument to enforce the test of exactness, as then these sciences would pass under a cloud of discredit. But the test cannot be accepted. His method of criticism would throttle every science in its growing stages before completeness of demonstration had been attained. He insists upon a criterion which would abolish half the sciences and strip the remainder of all validity and authority except in their perfected forms. Referring to his address, he remarks:

"But then, I said—and it was the whole purport of my speech made in the interests of science as well as religion—that we can only expect these results from true science, which investigates what Nature really *is*, and not from a hasty and presumptuous science, which pretends to give us what Nature *may be supposed to be*. And my criterion of true science, suggested in a phrase, was, that the methods and results of it bear the impress of exactitude or certainty."

Now, nothing is more certain than that we can never arrive at what Nature really *is* except through the pathway of "what Nature *may be supposed to be*." All science begins with guesses and conjectures, and its most valid laws were at first but suppositions. The evidence by which scientific truth is determined necessarily involves suppositions to which it has been applied, and these have to be gradually confirmed; hence, if exactitude is demanded at the outset, all science becomes impossible.

To get at the full bearing of this matter we quote the original passage as it stands in the revised address of the proceedings at the Tyndall Banquet. It reads:

"Science is exact and certain, and authoritative, because dealing with facts, and the systematic coördination of facts only. She does not wander away into the void inane. She has nothing to do with questions of primal origin, nor of ultimate destinies; not because they are unimportant questions or insoluble, but because they transcend her instruments and her methods. You cannot measure love by the bushel, as the children say; you cannot catch fancy in a forceps to analyze its elements; you cannot fuse thought in a crucible to detect what may be dross, and what sound metal."

We think that Mr. Godwin here lends countenance to a prevailing fallacy. Science is perpetually bidden to keep within her sphere, and the popular notion of her sphere is that of experimentation. To most people the word science connotes physical or experimental science. On this tacit assumption Mr. Godwin declares that cubic measure, forceps, and crucibles, are not applicable to love, fancy, and thought. Most true; but will he maintain that these are therefore not amenable to scientific scrutiny? As we understand it, science is a knowledge of the constitution of things; of the uniformities of the phenomena of Nature. Whatever, in the universe around us, or in the world within us, is open to cognition, which can be examined and known, and reëxamined and verified, is the proper subject-matter of science, and the term is applied to all the knowledge that has been arrived at in this way. An emotion may be analyzed and understood as well as a mineral. Love, fancy, and thought, cannot be subjected to laboratory processes, but they may be known in their laws and relations as mental phenomena, and in this aspect they belong as strictly to science as metals or gases. That they cannot be weighed makes no difference, because exactness is not the criterion of science. Mr. Godwin asks, Where, then, does the inexactness come in? To which we reply, wherever the instruments, by which exactness is reached, are inapplicable, or can only be imperfectly applied. The best criterion of science is derived from the fact of order and uniformity in Nature by which one thing implies another, and we in-

fer from what has been what will be again. It is *prevision*, that is, such a perception of the properties and relations of things as will enable us to see beforehand what effects will be produced in different times, places, and circumstances. Phenomena that elude measurement may yet occur with such regularity as to be foreseen with certainty. There is, in fact, a qualitative science which precedes quantitative, for properties must be known before they can be measured, but the test of prevision applies to the lower or qualitative stage as well as to the higher. Because biology, psychology, and sociology are not, and never can be, exact sciences, is therefore no reason for impugning their results as untrustworthy or without authority.

We quite agree with Mr. Godwin that Science is inexorably shut up in the finite and the phenomenal—the sphere of relation and law: but she must have the liberty of the whole domain. Nor do we think there is much danger of Science wasting her energies in trying to transcend these bounds, for she has plenty to do to get even partial possession of what confessedly belongs to her. She has won her ground, inch by inch, by hard fighting from the beginning, and even yet it is conceded to her only in name. Everybody will admit that it is the right of Science to inquire into all changes and effects in physical Nature. Yet, for suggesting that a given class of alleged physical effects be inquired into in the same manner as are other effects, Prof. Tyndall has been posted through Christendom as a blasphemer. Mr. Godwin yields to Science the realm of the finite and the relative, and in the same breath he speaks of the relations of Mozart to the laws of music, and of Shakespeare to the laws of the human heart, as examples of the trans-phenomenal. But we thought laws and relations had been made over to science. No reservation will here be tolerated. Science is providing for its ever-increasing army of research through a long future. Half a thousand years have been spent in getting on the track; another thousand will suffice to get under headway; she stipulates now only for room. Her sphere is the finite, but the nebulosities of ignorance must not be mistaken for the walls of the infinite. If mystics will lose themselves in the tangled recesses of unresolved phenomena, they must expect to be hunted out and have the place reclaimed to order and annexed to the provinces of all-harmonizing law. Nor can any pretext that they are nested in the unapproachable essences and subtleties of being, and ensphered in the absolute, and guarded by cunning sphinxes, avail them. The thing must inexorably be inquired of. It is the destiny of Science to pierce the unknown; if her spear is blunted upon the unknowable, she will of course accept the results of the experiment.

But, though scientists are hopelessly closed in, Mr. Godwin does not despair of others getting out, and he asks: "Is thought, whose expatiations are so restless and irrepressible, to be forever shut up to the phenomenal and relative? Is it to be forever stifled under a bushel-measure, or tied up by the legs with a surveyor's chain?" But the phenomenal and the relative go a great ways. Mr. Godwin talks as if "God's measureless world" were a stifling prison. We have been reminded that "Nature is a prodigious quantity," and we are so strongly impressed with this truth that we do not like Mr. Godwin's figure of a "bushel-measure" to symbolize its extent, any more than we like his favorite figure of "mud" to symbolize its quality. As to his question whether thought is to be tied by the legs with a surveyor's chain, we suspect that it is "tied" by something a good deal stronger than that: namely, by the laws of its own nature. He is skeptical about the science of psychology, and asks for its agreements. The

question we are now considering may be taken as an example. It is pretty well agreed by the latest schools that, as the universe exists in relations, so thought is carried on in relations, and, by its very constitution, cannot transcend them. It is agreed that as music in all its inexhaustible complications is still made up by the combination of simple wave-pulses, so intelligence, in all the range of its complications, is made up of the combination of perceived relations; and we might as well talk of the higher exploits of musical art as transcending the vibrations of which they are constituted, as of the "restless expatiations" of thought transcending the relations of which mind is constituted. Sir William Hamilton is fair authority, and he says: "Limitation is the fundamental law of the possibility of thought. For, as the greyhound cannot outstrip his shadow, nor the eagle outsoar the atmosphere in which he floats, and by which alone he may be supported; so the mind cannot transcend that sphere of limitation within and through which exclusively the possibility of thought is realized." We therefore fear that, should any adventurer break bounds on a winged horse, and take his flight through the ultra-phenomenal tracts, the tidings wafted back would prove altogether unintelligible.

Mr. Godwin says: "Am I to infer from your objections to my remarks that THE POPULAR SCIENCE MONTHLY holds materialism, atheism, and naturalism, to be the legitimate outcome of science?" Exactly the contrary. We do not believe that the legitimate outcome of science is materialism or atheism, and our attempt was to show that certain problems and procedures, which Mr. Godwin declared to be spurious science and obnoxious to these charges, were genuine science, and not obnoxious to them. We objected, in order to rescue a portion of science from an aspersive charge to which all science is equally liable. Büchner may be a materialist, and Comte an atheist, and Taine may be both, although it does not follow, because he affirms the correlation of mind with nervous motion, that he is either. What moved us to protest was the gross injustice of branding Mr. Spencer's expositions of the doctrine of Evolution as sham science, and then loading it with the opprobrium which its associations and the argument implied. Of Spencer's system, Mr. Godwin says, on his own and higher authority, that it is "full of unsupported assumptions, logical inconsistencies, and explanations which explain nothing, while in its general character it tends to the sheerest naturalism." We do not deny that it contains defects—it would be, indeed, surprising if so vast and original a discussion did not; but to say that it is "full" of the vices alleged, or that they characterize it, is a reckless exaggeration. As a set-off to this opinion, we refer the reader back to page 32, where he will find the latest estimate of Mr. Spencer's philosophy by a man who is an authority upon the question he discusses.

As to the religious "tendencies" of the system, although they are charged with being all that is bad, and although the charge would undoubtedly be sustained by a popular vote, we are of opinion that it is bound to be very differently viewed in the future. Mr. Spencer is a profound believer in religion, and at the very threshold of his system he has shown the ultimate harmony of science and faith. Yet he has not tried merely to patch up a transient truce between religion and science; but, foreseeing the intenser conflicts that are inevitable as science advances, he has labored to place their reconciliation upon a basis that no extension of knowledge can disturb. When the method of science is raised to its rightful supremacy in the human mind, and the rule of science is recog-

nized as supreme throughout the sphere of the phenomenal, and when the distractions of theology become unbearable, it will then be found that Mr. Spencer has proved that science, so far from being its destroyer, is itself the promoter of the profoundest faith, while the central truth of all religion is saved to humanity. Malignant zealots will probably continue to secrete their vitriolic criticism, as, if stopped, they would probably die of their own acridities; but there are not wanting indications that many religious men of candor and discernment are already recognizing the claims of Mr. Spencer's system upon the serious consideration of their class. For example, a late number of the *Nonconformist*, the organ of the English dissenters, and an orthodox paper of high influence, says of Spencer: "He is not an idealist, nor is he a materialist. Like Goethe, he believes that man is not born to solve the problem which the universe presents." Yet the writer holds his views to be of very great importance, and speaks of it as "an importance, in our opinion, so great, that the future, not only of English philosophy, but of practical theology, will be determined by its acceptance or rejection."

As for ourselves, differing widely from Mr. Godwin in his estimate of Spencer's system of philosophy, we record our opinion that, as it becomes more fully known, it will be recognized as an unequalled performance in its rigorous conformity to scientific method, and as the first grand alliance of science and philosophy; that it will exert an all-reconciling influence upon the chaos of doctrine; that, while based upon progress, it will prove powerfully conservative, and will leave all other systems behind in its value for guidance, both to the individual and the state. We believe that the time is not greatly distant when even theologians will seek it as a shelter against the rising tide of "materialism" and "atheism;" and, finally, we predict that, if Mr. Spencer lives to complete his "Principles of Sociology," with the accompanying tabular scheme of "Descriptive Sociology," that which Mr. Godwin says is now only a "hope" will become an assured and authoritative science—which is certainly one of the most imminent desiderata of civilization.

LITERARY NOTICES.

EDUCATION IN JAPAN. A Series of Letters Addressed by Prominent Americans to ARINORI MORI. New York: D. Appleton & Co., 1873. 255 pages.

AND now Japan comes forward to confound the theories of publicists, and give a new problem to political philosophers. An ancient Oriental nation, with a history stretching over 2,500 years, and claiming the oldest dynasty in the world, containing 34,000,000 people, and which has long been shut out from the world by its exclusive system, now throws open its gates to intercourse with other nations, and raises the great question as to how it may best acquire the highest benefits of civilization. Its youths are sent away to be educated (there are some 300 in this country), and learned foreigners are sent for, that the modern arts and sciences may be acquired, and there are even indications that this proud and exclusive people meditate a change of language, and the adoption of English in place of their native speech. The Japanese envoy at Washington, Mr. Arinori Mori, a liberal and well-educated young gentleman twenty seven years of age, has addressed a circular letter to a large number of the distinguished men of this country, asking their views and advice as to how the Japanese can best gain the advantages of education, free commerce, and enlightened industry, and best improve the social, moral, and physical condition of the Japanese people. The present volume embodies the replies which he received from Presidents Woolsey, Stearns, Hopkins, McCosh, Eliot, Profs. Seelye, Henry, Murray, Northrup, Whitney, the Rev. O. Perinchief, and the Honorables G. S. Bout-

well, J. A. Garfield, and Mr. Peter Cooper. Their replies are not only interesting as furnishing the information required for its practical objects, but they are also interesting as illustrating the way American scholarship engages with this novel and curious sociological problem. Mr. Mori has prepared an introduction to the volume, giving an historical sketch of Japan, and some account of the present condition of its government, religion, language, and people.

DISEASES OF THE URINARY ORGANS, including Stricture of the Urethra, Affections of the Prostate, and Stone in the Bladder. By JOHN W. S. GOULEY, M. D. With One Hundred and Three Wood Engravings. New York: William Wood & Co., 1873.

AMID the flood of medical works annually poured out for the doctor's guidance, it is a pleasure to find occasionally one that deals, in a clear and straightforward way, with the subject in hand, and is not encumbered with the endless theories and speculations of which medical writers are so prolific. The book before us is one of these exceptional productions in medical literature. It is in no sense a compilation, but embodies the results of an extended experience, both in private practice and in the hospitals of this city. Yet, while thus mainly founded on personal observation, the claims and teachings of the many eminent men who have illustrated this department of surgery have not been overlooked. The author does not undertake to go over the whole of this important department of medicine, but modestly limits himself to a few of the graver surgical affections of the male urinary organs, giving the pathology, clinical history, and treatment of each, with full and explicit directions for the various operations involved. Whenever the use of instruments is called for, he urges, with emphatic earnestness, the necessity for the utmost care in their employment; and this, to our minds, is not the least valuable feature of the book, since it is well known that these and other diseases are often seriously aggravated, and not unfrequently put beyond the reach of cure, by the bungling manipulations of over-confident and careless operators. Dr. Gouley's abilities as a practitioner are unquestioned, his success as a teacher has also been amply proved, and the present work gives evidence, both in matter and style, that he is entitled to rank equally high as a clear and instructive writer.

THE MICROSCOPE AND MICROSCOPICAL TECHNOLOGY. A Text-Book for Physicians and Students. By Dr. HEINRICH FREY. Translated from the German, and edited by George R. Cutter, M. D. New York: William Wood & Co., 1872.

WE welcome the appearance, in an English dress, of Frey's excellent work. It covers a far wider field than Martin's book, noticed in a recent number of THE POPULAR SCIENCE MONTHLY; indeed, the entire subject of microscopy and microscopical instruments is treated by Dr. Frey. The author devotes one-third of his work to the description of microscopic instruments, the testing of them, and their uses. To the section on "Testing the Microscope," the translator appends a few pages of original matter, giving the history of microscope-manufacture in the United States. He shows that microscopes of American manufacture possess all the excellences of foreign instruments, *plus* certain mechanical simplifications the product of American inventive genius.

The "Preparation of Microscopic Objects" has nearly 250 pages devoted to its treatment. This is a very important branch of the *technique* of microscopy, and the student will find here all the practical directions he needs, derived from the experience of the most eminent microscopists. The purpose of this portion of the work, as also of the section on "Mounting," is to save the student countless mortifying failures. Every microscopist may discover for his own use the best processes for preparing and mounting; but the time so spent is better spared, and devoted to practical investigation. The work of the microscopist is at all times exceedingly laborious, requiring a degree of patience and application that is almost incredible. The author aims in this part of his book to smooth away some of the difficulties attending the first approaches to this fascinating study; but, if any *dilettante* expects to find here a royal road to microscopy, he will be most assuredly disappointed. Of this branch of knowledge, it is preëminently true that only by hard work

can any progress be made. This portion of the work is of high value, and the information it contains is nowhere else accessible, at least in the English language.

The remaining 400 pages are devoted to explaining the mode of investigating the fluids and tissues of organisms, etc. The author's method here is, first, to ascertain the normal conditions of tissues, organs, etc., and then to study diseased conditions, the pathological structure always more or less repeating the normal. As far as we have had an opportunity of judging, the translator's work appears to be well done.

THE DEPTHS OF THE SEA. By C. WYVILLE THOMPSON, LL. D., etc. London and New York: Macmillan & Co., 1873.

CERTAIN new and very interesting results, in regard to the distribution of life, have been arrived at within the last few years, by dredging the bottom of the sea. Twenty years ago it was believed that at certain depths the greatness of the pressure, the lowness of the temperature, and the deficiency of light and aëration, made it impossible for life to subsist. The alleged cases of living creatures being drawn up from these great depths were discredited. The operations of cable-laying and cable-raising have, however, increased our familiarity with the bottom of the sea, and the improved manipulations have been turned to account in exploring its life. The result was, the establishment of the truth that there is an order of life belonging to the sea-bed in the profound abysess of the ocean. The recognition of this fact led to systematic attempts to carry on deep-sea explorations. In 1868 the steamer Lightning was placed by the British Government at the disposal of Dr. Carpenter and Mr. Wyville Thompson for the express purpose of submarine research, and the Porcupine was afterward assigned, for a more extensive series of surveys, to the same gentlemen, with the addition of Mr Gwyn Jeffreys, in the summers of 1869 and 1870. In the first of these cruises the greatest depth reached was 1,500 fathoms, but in the second they went to the depth of 2,500 or 3,000 fathoms. The present volume is a record of the results attained in these expeditions. It gives an account of the apparatus and instruments employed, of the forms of organization discovered, and much information regarding the physics of the ocean. It is splendidly illustrated and popularly written, with much humor, and the treatment, like the subject, is any thing but dry; it is a volume altogether worthy the interest and importance of its subject.

VAN NOSTRAND'S ECLECTIC ENGINEERING MAGAZINE. New York: D. Van Nostrand, 23 Murray Street.

WE call the attention of mechanics, engineers, manufacturers, and scientific students, to this able and valuable periodical, now in its eighth volume. It treats of the applications of science, constructions, mining, and technical processes, and gives the solid literature of these subjects from all sources. It is edited with excellent discrimination, and the bound volumes of the series would form a most useful cyclopædia of recent authentic information upon the subjects to which it is devoted.

HISTORICAL STATEMENT OF THE BUSINESS AND CONDITION OF THE MUTUAL LIFE INSURANCE COMPANY, OF NEW YORK, FOR THIRTY YEARS, FROM 1843 TO 1872.

THE company did well to state, in the beginning of this pamphlet, that its matter is important; since, owing to the style in which it is presented, few will be likely to discover that fact in any other way. Its contents are put in the shape of a facsimile of the original statement, signatures and all, a form to which probably not one in a hundred will attach any special value, and that involves a useless waste of time and patience on the part of the reader. What policy-holders and the public want is clear and explicit information that is readily accessible, and this appears to be just what the insurance companies are unable or unwilling to furnish.

HYGIENE: a Fortnightly Journal of Sanitary Science. New York: Putnam. Two dollars per year.

THIS is a publication that was much needed, for the first of all our interests, that of health, is the one concerning which people are most careless and indifferent. It is amazing the amount of ignorance displayed, even by cultured people, with regard to the

most evident precepts of sanitary prudence. This journal will, no doubt, do a good work in helping to diffuse abroad something like rational views as to the *conditions of health*. This periodical has nothing directly to do with medicine, nor will it attempt to make doctors of its readers. *Hygiene* is handsomely printed and carefully edited.

MISCELLANY.

Meteor-Showers on the Night of November 27, 1872.—In all quarters of the heavens, says an astronomical periodical, the *Leipziger Sternwarte*, the meteors were very numerous, especially in the Southwest and the Northeast. An observer looking toward the South counted within 54 minutes, soon after seven P. M., 700 meteors; another observer 807 meteors in 40 minutes. Between eight and nine o'clock 899 meteors were counted in 42 minutes, 304 in 19 minutes between nine and ten o'clock, 291 in 30 minutes between ten and eleven o'clock. Now, as the observer could view about one-fourth of the heavens, and as over 20 meteors per minute were observed at about eight o'clock, we must set down the number falling between seven and eight, and between eight and nine, at 5,000 per hour. The phenomenon began to fail at ten o'clock, and, between that hour and eleven, only 2,000 meteors fell. About one-sixth of these meteors were brighter than stars of the first magnitude, and many of them left a train which was luminous for several seconds. The majority of them were, however, between the second and fourth magnitudes. In color most of them were yellow, though some were green, some blue, some red; those of feebler lustre were white. Prof. Galle, of Breslau, and Prof. Klinkerfues, of Göttingen, agree in attributing this meteor-shower to the meeting of the earth with Biela's comet. "Without doubt," writes the former, "these meteors consist of scattered particles of Biela's comet, meeting the earth, as that comet in its septennial period passed that point in its career in the beginning of September, and was at its perihelion at the beginning of October. Schiaparelli's discovery of the connection between comets and meteoric showers thus obtains fresh confirmation."

Professor Agassiz's School of Natural History.—This establishment, which was at first designed for Nantucket, but is now intended for Penikese Island, had the following programme of subjects and instructions:

"1. Zoology in general, and embryology of the vertebrates, by L. Agassiz, Director of Museum. 2. The extinct animals of past ages compared with those now living, and the methods of identifying them, by N. S. Shaler, Professor of Paleontology at the Lawrence Scientific School. 3. Comparative anatomy and physiology of the vertebrates, by Dr. B. G. Wilder, Professor of Anatomy and Physiology at Cornell University, Ithaca, N. Y. 4. The animals and plants living in deep waters, and the peculiar conditions of their existence, by L. F. de Pourtales, of the United States Coast Survey. 5. Embryology of the radiates, by A. Agassiz, of the Museum of Comparative Zoology. 6. Natural history of embryology of the mollusks, by Prof. E. S. Morse, of Salem. 7. How to make biological collections illustrative of the history of insects injurious to vegetation, by Dr. H. A. Hagen, Professor of Entomology at Harvard University. 8. Natural history and embryology of the articulates, by Dr. A. S. Packard, Jr., Curator of Articulates at Peabody Academy of Science, Salem, and Lecturer on Entomology at Bowdoin College. 9. Natural history of the fishes and reptiles, by F. W. Putnam, Director of Museum of Peabody Academy of Science, Salem, and Permanent Secretary of the American Association for the Advancement of Science 10. Natural history of birds and mammals, by J. A. Allen, of the Museum of Comparative Zoology. 11. On breeding, and nests and eggs of birds, by Dr. Thomas W. Brewer, chairman of Committee on Birds, Nests, and Eggs, of the Boston Society of Natural History. 12. Practical exercises in the use of the microscope, by Mr. Bicknell. 13. Instruction in drawing and painting of animals, by Paulus Roetter, Artist at Museum of Comparative Zoology. 14. On the preservation of our sea-fisheries, by Prof. Spencer F. Baird, United States Commissioner of Fisheries, and Assistant Secretary of Smithsonian Institute. 15. On fish-breeding, by Theo. Lyman, of the Museum of

Comparative Zoology. 16. The fauna of the North Atlantic, compared with one another, and with that of other parts of the world, by Prof. Verrill. 17. The plants of the sea, by Prof. Eaton. 18. The physics of the sea, by Prof. Joseph Lovering, Professor of Natural Philosophy, Harvard University. 19. Physical hydrography, by Prof. Mitchell, of the United States Coast Survey. 20. Chemistry of feeding and breathing, by Prof. W. Gibbs, Rumford-professor of Physics, Harvard University. 21. Chemistry of the sea and air, by Prof. James Crafts, Professor of Chemistry at the Boston Technological Institute."

The Causes of Typhus.—As causes predisposing to typhus, medical writers usually enumerate mental depression, anxiety, fear of contagion, intemperance, insufficient nutrition, and overcrowding. Now, during the sieges of Paris and Metz, the inhabitants of those two cities were subject in an extraordinary degree to all these conditions, if in the case of Metz we except the fourth; and yet not a single case of the disease occurred among either the citizens, the refugees, or the soldiers. The beleaguering armies of the Germans, on the contrary, whose sanitary condition was infinitely better, were constantly ravaged by typhus. This conflict of facts with theory has led Dr. Chauffard, of the Paris Academy of Medicine, to investigate the subject of typhus anew, and we here give the chief results of his inquiry. According to him, the epidemics of typhus which have broken out in France had always a foreign origin, and the disease has never been able to become endemic in that country. The epidemic of 1814 was brought in by the defeated armies of the North, on their return from Russia and Northern Germany, and that of 1855–'56 was imported by the troops returning from the Crimea. But soon they died out on French soil, and hence the author conjectures that in the French race and on French soil there is something which is antagonistic to typhus. He inclines to regard this disease as localized, so far as its origin is concerned, just like cholera, or yellow fever. Then, to show that his conjecture as to race immunity is not without foundation, he states that in New Orleans the yellow fever commits its greatest ravages among the whites, the cholera among the negroes. Then, too, the negro race can better resist the morbid influences of marshy soil, than can the white. To show how different may be the effects of the same morbific influences on diverse races of men, the author cites the case of an Egyptian vessel entering the port of Liverpool in the worst possible sanitary condition. The crew were all sick—but no typhus. But the Englishmen who visited the ship were nearly all seized with that disease. On the high table-lands of Mexico, typhus is endemic and frequent, typhoid fever very rare. On the contrary, at an altitude of less than 2,000 feet above the sea-level, typhoid is abundant, typhus rare. Even on the table-lands, however, newly-arrived French soldiers were attacked by typhoid; but, when they had become acclimated, they were seized only by typhus. The author replies to the objection that might be drawn from the occurrence of typhus in prisons and among convicts condemned to the galleys, by claiming that such outbreaks of supposed typhus are really only typhoid fevers of an unusual character. In fact, ever since French physicians had, after the Crimean War, an opportunity for more closely studying true typhus, prison epidemics are not often characterized as outbreaks of that disease. The author then examines certain cases where undoubted typhus has made its appearance spontaneously, as it might be supposed, on French soil, and explains the occurrence by importation from foreign countries. Our brief abstract is far from doing justice to this highly-important paper, and we commend the entire essay, as found in the *Revue Scientifique*, to the attention of our medical readers.

Habits of Right and Sperm Whales.—In the *American Naturalist*, Prof. N. S. Shaler notes some of the prominent characteristic habits of right and sperm-whales, on the authority of an old whaler, Captain John Pease, of Edgartown, Massachusetts. The calving-time for the right-whale, he says, never begins until July 1st, and by the 3d or 4th of the month every female is accompanied by her calf. The affection of the right-whale

and of the humpback for their young is very strong, but the sperm-whale gives no evidence of such fondness. Among sperm-whales there is strict subordination of every herd to its leader, but each right-whale appears to be independent. The male right is smaller than the female, but the reverse is the case for the sperm-whale. The males of the sperm-whale engage in furious conflicts with each other, and Captain Pease has often found clear evidence of these fights in the scarred bodies of captured whales. In the Nantucket Museum may be seen two specimens of the lower jaw damaged in conflict, one of them being bent laterally into one turn of a spiral. Captain Pease has often witnessed the attack of the sperm on the right and humpback whale. Fifty or more of them will join in the attack, leaping many feet out of the water and falling on their victim. Squid forms the principal food of the sperm-whale, and Captain Pease once saw the head of a squid, as large as a sugar hogshead, which had been chopped off by the closure of the sperm-whale's jaws.

The captain is positive that a trace of hair is to be found within the skin of the right-whale, and says that, if the fresh skin be scraped, the inner section will show a trace of hair. If this whale is the descendant of a land-mammal, we should expect to find just such a trace of hair. Then, too, there is a sperm-whale's tooth at Nantucket which has two fangs, and it is stated that the other teeth of the animal to which this belonged had likewise two fangs. The author suspects here a case of reversion. According to Captain Pease, right-whales attain adult size in three years, though he admits that they may grow very slowly for some years longer.

Cruelties of the Seal-Fishery.—The cruel and useless destruction of young seals, resulting from the way in which the seal-fisheries are at present conducted, has called out a vigorous protest from Mr. Frank Buckland, coupled with a recommendation that the governments concerned unite in a system of regulations that shall in future prevent the barbarities and wastefulness which, if continued, must soon put an end to an important industry. On the authority of Captain David Gray, commander of the screw-steamer Eclipse, of the Scottish sealing-fleet, we are told that operations begin about the 20th of March, or within a few days after the young are born. The harpooner chooses a place where a number of young seals are lying, knowing that soon the mothers will make their appearance. Of these, as many as 40,000 were killed last year, not to speak of those that were wounded and scared away. Thus tens of thousands of young seals are left motherless. "It is horrible," says Captain Gray, "to see the young ones trying to suck the carcasses of their mothers, their eyes starting out of the sockets, looking the very picture of famine. They crawl over and over them until quite red with blood, poking them with their noses, no doubt wondering why they are not getting their usual feed, uttering painful cries the while. The noise they make is something dreadful. If one could imagine himself surrounded by four or five hundred thousand human babies all crying at the pitch of their voices, he would have some idea of it. Their cry is very like an infant's. These motherless seals collect into lots of five or six, and crawl about the ice, their heads fast becoming the biggest part of their bodies, searching to find the nourishment they stand so much in want of. The females are very affectionate toward their young." Immense numbers of young seals are in this way starved to death; and, even if slaughtered on the spot, are comparatively worthless, as their bodies contain little or no oil, and their skins bring but a very low price. According to Mr. Buckland, if the commencement of the work were postponed for only three or four weeks, the young would then be old enough to take care of themselves, and, even if killed, which he strongly objects to, at this early period of their lives, their bodies would have a greatly increased value.

The Failure of Car-Axles.—The fracture of car-axles, and the frequent accidents arising therefrom, are due, it appears, in the majority of cases, to imperfect construction, which may be readily detected by applying the proper tests. As an example of the kind of work that manufacturers sometimes turn out to railway com-

panies, we are told by Mr. James E. Whitney, in the *Railway Times*, that, of a lot of axles furnished to the Mobile & Ohio Railroad Company, but one-fourth were capable of meeting the required test, and the other three-fourths were returned to the manufacturer. Mr. Whitney also says that the duty of making these tests belongs to the railway companies themselves, which leaves them no valid excuse for the employment of defective materials.

Besides the use of poor iron, the resisting power of the axle may also be lessened by the method of manufacture. "The ideal axle," says Mr. Whitney, "would have its metal as dense as possible, and hence would be shaped mainly by hammering. Its fibres would run unbroken throughout its length, and the tough outer skin, which in wrought as in cast iron is much stronger than that within, would be preserved in its integrity." As now manufactured, a portion of this is removed by turning, and the axle proportionally weakened. The turning process is also carried to the formation of sharp corners, which, as shown by Rankin, eventually become the starting-points of annular or circumferential grooves that continue to deepen until the central portion is too much diminished to bear the shock of the unusual jar: "The ordinary 'tapping' will, in aggravated cases, enable such a flaw to be detected, but no skill and no care will guard against the slow but sure approach of danger, because of the unnecessary removal of a few annular chips at the shoulder of the wheel-bearing, to gratify the whim of the turner."

But, however strong originally, car-axles always deteriorate with use, the constant succession of jars to which they are subject gradually impairing the strength of the iron. The character of this change is not well understood, and the only effective method now known, of guarding against the danger arising from it, is to throw the axle aside after it has been run a certain number of miles.

Bowlder-like Masses of Clay in Drift.—Masses of stratified gravel, similar in shape to the clay-bowlders mentioned in the March number of this monthly as occurring in the drift of Long Island, were found during the excavation of the Chicago Tunnel in the drift under Lake Michigan. In the *American Journal of Science* for January, 1867, Prof. E. Andrews thus describes them: "They lay in all imaginable positions, sometimes with their strata set up at high angles. They were from a few inches to a few feet in diameter, and were embedded in the solid, impervious clay nearly 80 feet below the surface of the lake. The gravel was water-worn, and often so clean that it would scarcely soil a handkerchief. The interstices commonly contained a few gallons of water in the lower part, and some air or gas in the upper. The gas was in many instances inflammable. The pockets scarcely leaked a drop when once emptied, and the cavities looked exactly, in many instances, like casts of rounded bowlders."

Prof. Andrews believes they were deposited as frozen masses which thawed after they were embedded in the clay. This view is corroborated by an experiment made two years ago by Mr. E. Lewis, of Brooklyn. During a period of cold weather he selected an inlet of the sea through which the tidal flow was rapid, and in which the water was several degrees below freezing. The bottom was frozen where the water was 10 feet deep, but there was no ice on the surface. A mass of frozen earth weighing about 50 pounds was sunk, by means of a cord, at the deepest part of the inlet. Six days afterward this mass was unchanged, except that its extreme surface was slightly soft and moist. At the expiration of 30 days it was again examined, and found to be somewhat wasted. The temperature of the water was then 3° above freezing. "If," says Mr. Lewis, "this mass had been covered by a quantity of sand or gravel, thrown down upon it while frozen, it would have retained its form; and enormous masses of such material are sometimes deposited suddenly from floating ice and glaciers."

Marked Case of Heredity in Mastiffs.—Mr. Darwin communicates to *Nature* a letter from Mr. Huggins on the hereditary transmission, in a breed of mastiffs, of a strong antipathy to butchers and butchers' shops. Mr. Huggins owns a dog, "Kepler," whose sire was a celebrated mastiff, "Turk." When "Kepler" was six months old he fol-

lowed a servant out on the street, and then for the first time saw a butcher's shop. The animal threw himself down, and could not be induced to pass the place. The dog is now nearly three years old, and the antipathy has diminished somewhat, but not disappeared. Mr. Huggins lately found that "Kepler's" ancestor, "Turk," manifested the same antipathy, and his former owner was asked for information on the subject. It now appears that this curious dislike for butchers' shops and butchers was shown equally by "Turk's" sire, "King" (in whom it probably originated), and by "Punch" and "Paris," sons of "Turk." The antipathy is most marked in "Paris," who will hardly enter a street containing a butcher's shop, and runs away after he has passed it. If a butcher's cart comes to the place where the dogs are kept, they are filled with fright even though they do not see the object of their fears. "Turk's" owner, Mr. Nichols, then tells of two instances where "Paris" gave evidence of the most extraordinary sagacity in recognizing a butcher under any circumstances. One evening a boss-butcher, in ordinary clothes, called to see "Paris," but had scarcely entered the house when the dog became unmanageable, and the visitor had to leave without seeing him. On another occasion "Paris" sprang at a gentleman, and, as it was the first exhibition he ever had made of such viciousness, his owner apologized, and said that the dog had never before attacked any but butchers. The gentleman *was* a butcher!

Since the publication of Mr. Huggins's letter, several other communications have appeared in *Nature*, showing that all the dogs of this line inherit this instinctive antipathy. Mr. H. G. Brooke writes of a grandson of "Turk:" "Ever since he was a pup he has evinced" this antipathy. A brother of this dog of Mr. Brooke's shows the same feeling, according to Mr. Arthur Ransom, his owner.

Mr. Russel Wallace is inclined to think that these dogs distinguish butchers from other men by the sense of smell, which is very acute in all dogs. He also thinks that it it this sense which enables a dog to find his way back from a distance, though on first making the journey he had been blindfolded, and so prevented from seeing his way. Another correspondent of *Nature*, writing in confirmation of Mr. Wallace's view, tells of a cat's antipathy to dogs. This animal would "swear," if only stroked by a hand which had directly before touched a dog. Mr. Darwin's purpose in calling attention to the present case of heredity is, to illustrate his theory of instinct as an acquired and transmitted habit.

Changes in River-Beds.—In a report on the subject of a water-supply for the village of Yonkers, New York, published in the January number of the *American Chemist*, Prof. J. S. Newberry furnishes some interesting facts on the geology of river-beds, that will be of general interest. He says: "It is probably known to you that most of the draining streams of all the region between the Mississippi and the Atlantic are now running far above their ancient beds. This fact was first revealed to me by the borings made for oil in the valleys of the tributaries of the Ohio. All these streams were found to be flowing in valleys, once deeply excavated but now partially filled, and, in some instances, almost obliterated. Further investigation showed that the same was true of the draining streams of New York and the Atlantic slope. For example, the valley of the Mohawk, for a large part of its course, is filled with sand and gravel, to the depth of over two hundred feet. In the Hudson the water surface stands now probably five hundred feet above its ancient level—the old mouth of the Hudson and the channel which leads to it being distinctly traceable on the bottom nearly eighty miles south and east of New York The excavation of these deep channels could only have been effected when the continent was much higher than now. Subsequently it was depressed so far that the ocean-waters stood on the Atlantic coast from one hundred to five hundred feet higher than they now do. During this period of submergence the blue clays in the valley of the Hudson—the 'Champlain clays'—were deposited, and the valleys of all the streams were more or less filled."

Dimensions of New-England Glaciers.—The Glacial and Champlain Epochs in New

England is the subject of a learned paper, by Prof. Dana, in the *American Journal of Science* for March. From it we learn that in Northern New England the glaciers were from 5,000 to 6,500 feet in thickness. At the White Mountains the ice-surface was 6,000 feet above the sea-level, and the mass had a depth of nearly a mile. On Central Long Island the surface of the glacier was 2,100 feet above the surface of the sea, and in the Connecticut Valley 3,200 feet. The slope of the ice-surface from the White Mountains southward was about 24 feet to the mile, and about 19 feet to the mile in the Connecticut Valley. The glacier extended beyond the present coast-line, possibly some 90 miles southward of Long Island. Its forward movement is thought to have been one foot in a week, or about 100 miles in 10,000 years. The crushing and erosive power of such an enormous mass of ice may be appreciated when it is known that, if 6,000 feet thick, it would lie upon the earth with a pressure of about 300,000 pounds to each square foot.

NOTES.

A MONUMENT is to be erected in Birmingham, England, to the memory of Dr. Joseph Priestley. In his lifetime his heterodoxy disqualified him for a berth in one of Captain Cook's ships, though he would have been a most valuable aid to the commander. The time has at length come when England and America can do honor to the man who "embraced what is called the heterodox side of every question."

FIVE living sea-fish were recently sent by mail from Naples to London, the journey consuming a little over four days. The fish were each about two inches in length, and were packed in damp sea-weed, from which all but one came out in good condition, and, soon after being placed in their natural element, became as lively as ever.

PROF. LEIDY is of opinion that contagion is frequently transferred from one subject to another by the agency of the common house-fly, and his observations in military hospitals have led him to the conclusion that flies should be carefully excluded from wounds, particularly if gangrene is anywhere about.

WELTWITSCH tells of a plant, an oxalis, growing in Angola, Africa, which is so sensitive that it closes its leaves on hearing (so to speak) a footfall in its neighborhood.

A DYING pauper in Ireland willed his body to a surgeon for dissection. The poor-law guardians are indignant, and demand that the surgeon, who is medical officer to the Board of Charities, resign. The ground on which it is sought to annul the pauper's will is, "undue influence." This is probably the first case in which a pauper's last will and testament is brought into dispute.

BERLIN has grown rich by war, but her poor are growing poorer. About half of the population live in dens which have usually two chalk-lines crossing each other on the floor. A room is thus divided into four compartments, one for the sleeping-place, another for the nursery, the third is hired to a lodger, and the fourth is kitchen, living-room, and workshop.

A SAN FRANCISCO paper says that oysters can be imported into California from Mexico at a cheaper rate than from New York. The coast of Mexico, from Guaymas to Acapulco, abounds in oysters of large size and excellent flavor. They can be put on board the Mexican steamers at Mazatlan, at less than $15 per ton, and the freight thence to San Francisco would not be over $10.

THE following is in striking contrast to the "devil-may-care" policy of our laws in regard to the safety of railway-passengers: In England it is against the law to attempt to get on or off a railway-train while in motion, and, more than that, the law is enforced. Recently a young man nearly lost his life in the attempt to board a train which was slowly moving out of a station. He was brought up for trial, and fined five shillings with costs. A woman who stepped off a moving train was also convicted, and, having no money, was sent to jail for ten days. Americans, about to travel in England, may save some of their loose change and perhaps their personal liberty, by making note of this.

PROF. VOGHT records an instance of what may be called self-cannibalism. He cut in two a male cricket, and immediately the fore part, probably experiencing a sensation of emptiness in the ventral region, turned upon the hinder part and devoured it!

A FRENCH apothecary has discovered an excellent and very cheap substitute for quinine, in powdered laurel-leaf. The leaves of the laurel (*Laurus nobilis*) are slowly dried over the fire in a close vessel, and then powdered. One gramme (15½ grains) is a dose, and is taken in a glass of cold water. The drug so taken produces no bad effects, and soon, it is said, breaks up the most obstinate intermittent fevers.

PROFESSOR LIEBIG.